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MINUTES OF PROCEEDINGS

OF THE

ROYAL ARTILLERY INSTITUTION.

VOLUME XV.

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Colonel J. S. Owen RA

PRÉCIS

OF

LYDD EXPERIMENTS,

AUGUST AND SEPTEMBER, 1884.

IN CONTINUATION OF THE ACCOUNT OF THE LYDD EXPERIMENTS, PUBLISHED IN VOL. XIV., No. 14, of R.A. INSTITUTION "PROCEEDINGS."

BY

COLONEL F. G. BAYLAY, R.A.

OBJECT OF EXPERIMENTS.

THE main object of the experiments recently carried out at Lydd was to determine :—

1. The penetration into and effect on parallels and approaches of projectiles fired from 'quick firing' (Hotchkiss) and from field and medium B.L. guns.

2. The effect of the fire of machine guns on various forms of approaches.

3. The amount of overhead cover necessary to protect field magazines from high-angle common shell fire, when delay-fuzes are used.

4. The amount of accuracy and effect obtainable in the curved or high-angle common shell fire of medium B.L. guns, with *reduced* charges, against concealed revetments or earthworks.

5. The effect of gradual exterior slopes in deflecting projectiles on striking earthen parapets.

6. The relative value of bursting charges of different natures of powder when employed, in steel common shell, for the destruction of earthworks.

7. The number of rounds required (with various pieces of ordnance) to dismount a gun, on an overbank carriage, at a range of 2,400 yards, by frontal fire.

The experiments were divided into the following series :—

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DETAIL OF SERIES.

Series.	Ordnance.	Target.	Range.	Projectiles.	Fuze.	No. of rounds.
			yards.			
1st	6-inch B. L. gun 5-inch " " 12-pr. B. L. gun	1st parallel	800	Common shell, filled.	Percussion.	20 each piece.
2nd	6-pr. quick-firing B. L. Hotchkiss gun 12-pr. B. L. gun 5-inch B. L. gun	2nd parallel	400	Common shell, plugged.	Nil.	20 each piece.
3rd	6-pr. quick-firing B. L. Hotchkiss gun 12-pr. B. L. gun 5-inch B. L. gun	2nd parallel	400	Common shell, filled.	Percussion.	20 each piece.
4th	6-pr. quick-firing B. L. Hotchkiss gun 12-pr. B. L. gun	Single sap	300	Common shell, filled.	Percussion.	20 each piece.
5th	4th series repeated at	Double sap	...	...	...	...
6th	4th series repeated at	Blinded sap	...	...	...	...
7th*	Nordenfelt 1-inch gun Gatling gun	Single sap	300	Service cartridges.	...	...
8th*	7th series repeated at	Double sap	...	...	...	...
9th*	7th series repeated at	Blinded sap	...	...	...	...
10th*	Not carried out.	(Cancelled)	...	...	...	...
11th	8-inch R.M.L. howitzer	Field magazine	2400	Common shell, filled.	Special delay-action.	30
12th	6-inch B. L. gun	27 ft. x 18 ft. wood target and earthen parapet.	1600	Common shell.	Direct-action.	20
13th	6-inch B. L. gun 8-inch R.M.L. howitzer	30 ft. earthen parapet, with gradual exterior slope.	1200	Common shell, filled.	Direct-action percussion.	20 each piece.
14th	6-inch B. L. gun	30 ft. earthen parapet.	1200	Steel shell, filled with— 1. Shell, L. G. 2. P. and pistol mixed.	...	10 of each.
15th	6-inch B. L. gun 6·6-inch R.M.L. gun 5-inch B. L. gun 8-inch R.M.L. howitzer	Overbank gun mounted behind a 30 ft. earthen parapet, with screen in front.	2400	Common shell, filled.	Percussion.	30 each piece.

* Machine guns.

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SERIES 1.

Field and Medium Guns at Parallels.

CONDITIONS OF FIRE.

Ordnance.	Charge.	Angle of Descent.	Striking velocity.	Fuze.
		° ′	f. s.	
6-inch B. L. Gun, Mark II.	34 lb. P².	0 58	1466	Large percussion.
5-inch " " I.	16 lb. P.	0 53	1520	Small "
12-pr. Gun	4 lb. P.	1 5	1320	" "

The object of this series was to ascertain the effect of the common shell fire of field and medium B.L. guns against a first parallel (as at present constructed) at a range of 800 yards.

6-inch B. L. Gun; Shell, 100 lb.; Bursting Charge, 6 lb. 8 oz.

The results obtained showed that the parapet was breached by every round, fired from the 6-inch B.L. gun, which hit it, even when the shell struck close to the ground line.

It did not appear that any of the shell broke up on impact, which is probably to be accounted for by the fact of the parallel being of comparatively slight profile and of loose material, viz., lumps of unrammed clay, and hence it is likely that the heavy (100lb.) shell started the whole mass in front of it on striking, and therefore never encountered sufficient resistance to cause the shell to break up. It may be as well here to observe that in previous experiments the majority of similar shell fired into solid 30-feet parapets at ranges up to 1,200 yards have broken up; and, in some cases, *all* have done so.

5-inch B. L. Gun; Shell, 50 lb.; Bursting Charge, 3 lb. 8 oz.

The fire of the 5-inch B.L. gun, with its lighter shell and bursting charge, was naturally considerably less effective than that of the 6-inch gun; nevertheless, it was found that one round sufficed to breach the parallel, unless it happened to strike very near the ground line, in which case a second round was required.

In order to ascertain whether these shells were liable to break up on impact when, as in this case, the striking velocity was 1,520 f.s., several shells were fired, plugged with their charges drowned, with the result that all that hit the parallel low down broke up, hence it is evident that the destruction of the work was due almost entirely to force of impact, for although the bursting charge was ignited, there was little or no force of burst.

12-pr. B. L. Gun; Steel Shell; Bursting Charge, 1 lb. 12 oz. (P. and F. G. mixed).

This gun was fired at the parallel to arrive at the measure of its power in attacking earthworks, and gave very good results, about four rounds sufficing to breach the work, unless impinging very near the ground line, in which case about six rounds would be required.

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Series 2.

Penetration Trials.

The object of this series was to ascertain the penetration of plugged projectiles fired into earthworks. The target was a short length of second parallel at a range of 400 yards.

The conditions of fire were as follows:—

Ordnance.	Charge.	Angle of Descent.	Striking velocity.
		° ′	f. s.
Hotchkiss 6-pr. quick-firing gun...	1·95 lb.	0 25	1600
12-pr. B. L. Gun, steel shells	4 lb. P.	0 25	1500
5-inch B. L. gun	16 lb. P.	0 22	1655

Hotchkiss 6-pr. Cast-iron Shell.

The following results were obtained, 20 rounds being fired from each piece:—

Maximum penetration . . . . 12 feet.
Mean " . . . . 10 "
7 shells broke up on impact.

12-pr. B.L. Gun; Steel Shell.

Maximum penetration . . 24 feet.[1]
Mean " . . 17 " through at ground line
1 shell buckled and split at side.

5-inch B.L. Gun; Cast-iron Shell.

Shell all broke up on impact.

Series 3.

Hotchkiss, Field, and 5-inch B.L. Guns at Second Parallel.

In this series filled common shell were fired from the following pieces at a portion of second parallel, at a range of 400 yards:—

Conditions of Fire.

Ordnance.	Charge.	Angle of Descent.	Striking velocity.	Fuze.
		° ′	f. s.	
Hotchkiss 6-pr. quick-firing gun	1·95 lb.	0 25	1600	Base percussion.
12-pr. B. L. gun, common steel shell	4 lb. P.	0 25	1500	Small "
5-inch B. L. gun, common shell	16 lb. P.	3 22	1655	" "

[1] Shell turned down under parallel.

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Hotchkiss 6-pr.

The projectiles fired from this piece were cast-iron shell containing a 4-oz. bursting charge.

From the small weight of bursting charge the craters formed were but small; nevertheless, owing to the accuracy of the gun, and the high-striking velocity of its shell, the work was cut through in 15 rounds.

The effect of a piece of this nature is more marked when employed for the dispersion of small masses of earth, such as sap-heads, the first executed' portions of saps, &c., than when directed against such comparatively solid works as parallels, for the speedy demolition of which considerable shell-power, or momentum of projectile (or the two combined) is required.

12-pr. B.L. Gun.

The steel shell of this gun (containing 1lb. 12 ozs. of P. and F.G. powder mixed) made craters of considerable size. Round 1 struck the parallel 3 feet above the ground line, penetrated 2 feet to point of burst, and formed a crater 2 feet in depth and 4 feet in diameter.

Round 2 struck in the crater formed by the first round, deepening and enlarging it.

Round 3 struck about the same place, and breached the parallel, blowing away one gabion of the revetment.

5-inch B.L. Gun.

The results obtained appeared to indicate that one round taking effect about half way up the parapet was capable of breaching it effectually, and that a second, striking low down in the same line, would thoroughly open up the work nearly down to the ground line. It appeared that all of the shell broke up on impact.

GENERAL REMARKS ON SERIES 1, 2, AND 3.

The question arises, under what circumstances the besieged would ever think it worth their while to open fire on parallels; having regard to their great length, the comparative ease with which any damage inflicted on them could be repaired, and the uncertainty of such fire proving destructive to the troops occupying the trenches. Now, although it may be conceded that 'to afford concealment from view' and strong musketry positions are the chief offices of parallels, yet instances may occur in which it would certainly be desirable that they should afford efficient protection to the troops manning them from the effects of such artillery fire as might reasonably be expected to be brought to bear on the works of the attack.

For instance, in the case of a sortie, the guard of the trenches would of necessity discover their position on opening fire, and if, under such circumstances, nearly every shell taking effect on the parallel cut right through it, sweeping away masses of the parapet, with the defenders in the rear, the effect could scarcely fail to prove disastrous.

This being the case, it becomes a question worth considering

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whether some modifications in the construction of such works could not with advantage be introduced, either by going deeper, or by procuring extra earth from a trench in front of the parallel, according to the circumstances of the case.

Certain portions of parallels might at any rate be strengthened by these, or by some other means, in those situations where the troops holding the trenches would be the most likely to be called upon to man the works and open fire for repelling sorties, or where the parallel covers an approach.

SERIES 4, 5 AND 6.

Hotchkiss and Field Guns at Saps.

In these series a few rounds were fired from the Hotchkiss 6-pr. quick-firing gun, and from the 12-pr. B.L. gun, at a range of 300 yards at portions of:—

Single deep sap; double sap; blinded sap.

The results obtained showed that, even with the less powerful piece, (the 6-pr. Hotchkiss) very few rounds sufficed to effectually demolish the sap-heads, and also, in the case of the single sap, the 'earlier-executed' portion of the work. With regard to the blinded sap, the frame capsills, being exposed as soon as the sap-head was demolished, were soon cut through, leading to the fall of the overhead cover.

From this it would appear that, in cases where it is considered advisable to blind certain portions of the approach, such blinded portions should be in rear of, and protected by, the parapets of one or more traverses formed in the usual manner by changing direction.

With the 12-pr. the effect was naturally far more rapidly destructive, and the only conclusion that could be drawn was that it would be impracticable to push forward sapping operations by day so long as fire, of the nature indicated, could be brought to bear on the approaches.

It is, however, reasonable to suppose that the besiegers would keep a certain number of accurate rifled pieces advantageously posted, with the special object of silencing any fire of this nature which the besieged might bring to bear on the works of the near approach.

SERIES 4 (EXTRA.)

Target, shallow kneeling sap.

The practice in series 4 was in the original programme intended to be solely at a single deep sap; but a sap roller having been received from Chatham, it was decided to try the effect of a few rounds of common shell from the 12-pr. B.L. field gun and the 6-pr. Hotchkiss quick-firing gun at the sap-head of a shallow kneeling sap under the following conditions:—

Range, 300 yards.
Direction of sap, inclined to line of fire at 30°.

12-pr. B.L. Gun.

The steel common shell fired from this piece were found to burst

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about half way through the sap roller, cutting a large hole in the reverse side; the dummies in the head of the sap were struck by the splinters of shell.

The sap roller was not, however, displaced from its position.

6-pr. Hotchkiss.

The cast-iron common shell of the Hotchkiss were found in like manner to burst in the sap roller without displacing it. The fragments of shell appeared to search the head of the sap thoroughly. One gabion which was struck was displaced.

SERIES 5 (EXTRA).

12-pr. 'Ring' Shell. Target, Sap head of double sap.

A few rounds of 'ring' shell were fired at the sap-head of a double (deep) sap at 300 yards to try the effect of these projectiles which assimilate to the old pattern segment shells.

It was found that the shell burst in the sap head with destructive effect, cutting it down and sending numerous fragments and splinters into the trench.

Much the same effect would in all probability be produced by shrapnel shell with percussion fuzes.

SERIES 7 (EXTRA).

1-inch Nordenfeldt at shallow kneeling sap.

A section of shallow kneeling sap was next fired at, at a range of 300 yards, with the 1-inch Nordenfelt machine gun.

A $\frac{3}{16}$-inch steel shield (Knight's) was placed next the sap roller. The sap roller was pierced by the steel bullets, as were also those filled gabions which were not protected by earth in front, but the shield proved effective in deflecting a projectile which struck it after passing through a filled gabion.

·45-in. Gatling; 1-in. Nordenfeldt. Target, flying trench work.

A short length of flying trench work was fired at, at a range of 100 yards, with the ·45-inch Gatling and 1-inch Nordenfelt machine guns.

Gatling.

Half filled gabions, filled gabions, and $\frac{3}{16}$-inch steel shields, unprotected by gabions, were fired at with the Gatling with the following results:—

Half filled gabions,—some bullets through.
Filled gabions,—none through.
Shields,—indented but not perforated.

Nordenfeldt.

Bullets through shield and filled gabions, except where the latter were protected by earth in front.

In these extra series considerable information was gained regarding the power and destructive effect produced by the projectiles employed;

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but there is no reason to doubt that the superiority and power of concentration of fire possessed by the attack would enable the besiegers to speedily quell any fire of the nature indicated which might be brought to bear on their works.

Series 7, 8 and 9.

Machine guns and saps.

The object of these series was to ascertain the effect of the fire of machine guns on various approaches.

The machine guns employed were the ·45-inch Gatling and the 1-inch 4-barrelled Nordenfeldt at a range of 300 yards.

The penetrative power of the ·45-inch Gatling only exceeds, by very little, that of the Martini rifle, and the effect of its fire when directed against sap-heads was very slight, only quite the upper portion of the heap of sand bags being here and there penetrated.

The 1-inch Nordenfeldt was far more effective as regards penetration, but no doubt the amount of material in the sap-heads would always be regulated by the nature of the fire to which they were exposed, and having regard to the large amount of protection afforded by the deep sap (4 feet 6 inches) it is unlikely that the progress of such works would be arrested by the fire of machine guns. No doubt their fire would be annoying and more or less obstructive, dependent, in a measure, on the command over the approaches of the positions in which the pieces were worked; hence it would be incumbent on the besiegers to take effective steps for keeping down fire of this nature.

Series 10.

Series 10 was not carried out.

Series 11.

Thickness of earthen overhead cover necessary to protect field magazines from the effect of high-angle fire, with common shell having delay-action fuzes.

Before entering upon an account of this experiment it will be instructive to glance briefly at the results obtained in the Ordnance Committee Experiments at Lydd in 1882 and 1883.

In 1882 the overhead cover of the magazine was of ordinary construction, as laid down in the School of Military Engineering text book, and the common shell were fired at it from the 6·6-inch and 8-inch howitzers with direct-action (quick) fuzes.

With a striking velocity somewhat under 500 f.s. the fuzes admitted of so little penetration to point of burst that the deepest craters were only 3 feet 6 inches in depth; consequently the magazine was uninjured, and it became evident that unless at least two shells fell in succession on precisely the same spot (an improbable contingency) the explosion of the magazine could not be secured.

In 1883, no delay-action fuzes being available, it was sought to imitate their action by employing unbored 30-seconds wood time fuzes with detonators and thin (·012-inch) suspending wires.

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The experiment was fairly successful, and although some of the fuzes were driven in on impact and burst the shell immediately, others gave long delay, and the conclusion arrived at was, that a field magazine, as ordinarily constructed, would require some additional protection to enable it to keep out shells with delay-action fuzes.

In 1884 the Royal Laboratory undertook to provide two descriptions of delay-action fuzes, one kind intended for screwing into the nose, and the other for insertion in the base of the shell, both kinds so constructed as to be prepared to act with the small charges used with howitzers in high-angle fire.

The overhead cover of the field magazine first fired at consisted of one layer of fir baulks, 12 feet 10 inches × 10 inches, strengthened with two layers of light single-headed iron rails (36 lb. and a few 24 lb. rails) arranged at right angles to the fir baulks, which were afforded additional support by baulks placed outside the frames, and the thickness of earth overhead was increased from 5 to 7 feet.

8-in. Howitzer; 70 cwt.

The conditions of fire were as follows:—

Range, 2,400 yards.
Projectile, filled common shell, weight 180 lbs.
Bursting charge, 14 lbs. (nearly) shell, L.G. powder.
Fuze, experimental (nose) delay percussion.
Charge, 4½ lbs. R.L.G.[2]
Angle of descent, 33° 12′.
Striking velocity, 486 f.s.

Twenty-six rounds were fired, under very favourable atmospheric conditions, with the following result:—

Abnormal (error in charge)	1
Under	6
Over	7
Hits (not effective)	4
Hits (effective)	4
Short, but partially effective, as they moved a large amount of earth from the slope of the magazine	4
Total	26

Action of the fuzes.

Not observed	1
Blind[1]	6
Burst without delay	1
Burst with delay	18
Total	26

[1] A slight alteration has been made in these fuzes, to guard against 'blinds' in future.

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The amount of delay which the fuzes gave appeared to be about half a second.

From this abstract it will be perceived that eight shells fell on the earthen cover of the magazine, and four, which were just short, were enabled, by the delayed action of the fuzes, to get under the exterior slope and to blow away a large mass of earth.

Of the four hits classed as 'not effective,' one blind shell penetrated about 18 feet of earth, and lodged near the overhead timbers; had this shell not been blind, it would in all probability have produced important results. Two grazed the top, and only displaced a little earth, and the other lodged in the exterior slope, blew away a good deal of earth, but did no serious damage.

The four effective rounds were Nos. 9, 20, 24, and 26.

No. 9 hit exterior slope high up near the left flank[1] of the magazine, penetrated about 13 feet, burst after delay, forming a crater 14 feet in diameter, and about 7 feet deep. The force of the explosion blew in the left end of the magazine (which was it should be observed, 27 feet long[2]) breaking several frames, and filling that end of the magazine with *débris*. It is hardly likely that this shell would have injured a magazine of the usual length (12 feet), but the round was instructive, as indicating the large results, in the way of earth displacement, secured by the employment of these powerful shells with delay-action fuzes.

Round 20 hit top of magazine, near exterior slope, penetrated 18 feet to 20 feet of earth, and burst as it passed through the sheeting into the magazine opposite the entrance passage, the splinters cut up the frames very greatly, and many fragments of the shell were buried more than their own depth in the overhead baulks. This round would certainly have blown up the magazine.

Round 24 struck top of magazine, near exterior crest, penetrated about 18 feet and burst, blowing a large mass of earth outwards, and the right end of the magazine inwards. Whether this round would have exploded the magazine is doubtful.

Round 26 struck top of magazine, penetrated about 12 feet, and burst on the rails of the overhead cover, broke a number of rails clean in two, also five of the overhead baulks; several of the other baulks were considerably injured. All the end of the magazine opposite the entrance was broken in overhead and filled with *débris*. Even if this round would not have blown up the magazine, it would have rendered it incapable of being used, as it could not be entered.

From the results, so far obtained, it appeared that the penetration of the shells into solid, well rammed, and fairly dry clay was from 15 feet to 20 feet.

It was further evident that such penetration admitted not only of the

[1] The terms 'right' and 'left' refer to the line of fire from the battery to the magazine.

[2] The magazine was constructed with an extra length of 15 feet, in order to give a larger area for testing the effect of shells on the overhead cover.

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shells reaching the overhead cover, but also of the front side of the magazine being penetrated by those passing just short of the overhead baulks.

In the former case the powerful bursting charge (being well tamped with 7 feet of earth), sufficed to break the rails and baulks and to destroy the structure, and in the latter case the resistance offered by the frames and sheeting was of course so small that the projectile entered and burst inside the magazine with destructive effect.

Furthermore, that any shell lodging in the earth mass, with a line of least resistance in the direction of the magazine, would blow in the side, even if 6 feet or 7 feet of earth intervened between it and the sheeting.

Although it may fairly be urged that magazines would always be screened, and protected from the enemy's view, yet at the same time, if it be worth while to give overhead cover at all, such cover should certainly be capable of keeping out chance shell.

In order to afford further overhead protection, and to guard against the liability to be pierced *through the front side*, the magazine, when re-constructed under the supervision of Lieut.-Colonel Leach, R.E., was made with an extra layer of fir baulks 12 feet × 10 inches × 10 inches with a double layer of iron rails over them, and this extra protection was so placed in the earthen overhead cover as to intercept any shell that might strike near the exterior crest and take a line towards the front side of the magazine.

The magazine itself was covered with one layer of oak baulks 12 feet × 12 inches × 12 inches and a double layer of 36 lb. rails with 7 feet of earth above the ground line.

It may be as well to here observe that, unless checked in its course, a shell striking about the exterior crest would reach the sheeting after passing through about 20 feet of earth.

When fire was opened at the re-constructed magazine 16 rounds of ammunition only were available, and they were of the following descriptions:—

	No. of rounds.	Description of shell.	Bursting charge. lb.	oz.
'A'	3	Cast-iron common shell of service pattern; length 3 calibres.	13	10
'B'	10	Experimental cast-iron common shell; very sharp pointed, their heads being struck with a radius of 6 diameters; length, 3·62 calibres	11	5
'C'	3	Experimental steel common shell; heads similar to pattern 'B'; length, 4·08 calibres	21	11

The 'A' service pattern shells were fired with an experimental nose delay-action fuze as before, and patterns 'B' and 'C' with an experimental base delay-action fuze.

The other conditions of fire were the same as in the first part of the series. A fairly steady breeze prevailed during the practice, blowing nearly in the direction from the battery to the magazine.

The practice was unusually good, inclining one to the belief that the six-diameter headed shell were, notwithstanding their length, superior

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as regards stability in flight to the service common shells of three calibres. The spiral of rifling of the 8-inch howitzer increases to one turn in 35 calibres at the muzzle, which is probably sufficient for a 4-calibre shell with its centre of gravity well placed, when fired with this charge (4½ lbs.)

Results of fire.

Under	4
Over	2
Hit	10
Total . .	16

N.B.—In the first practice only 8 hits were obtained out of the 26 rounds fired, and on a somewhat calmer day.

In order to save time, a detailed account is only given of those rounds in which the shell struck the earth mass covering the magazine, and produced more or less important results.

Round 2, pattern 'B' cast-iron shell burst after delay under the left rear corner of the extra layer, broke seven rails, and displaced about ten cubic yards of earth; interior of magazine uninjured.

Round 5, pattern 'C' steel shell struck centre of berm in front of magazine, burst after delay, forming a very large crater.

Round 6, pattern 'C' steel shell struck 2 feet above the berm on crater formed by the preceding round, burst after delay in the earth mass apparently some five or six feet from the front frames, blew in the whole of the front of the magazine, which was about one-third filled with earth and *débris*; the beam for affording additional support to the overhead baulks was also blown into the magazine, and the frames and sheeting broken up.

Hardly any earth was disturbed externally, but on a way being cleared through the *débris* to examine the crater (which somewhat hazardous operation was performed by a corporal of the Royal Engineers), it was found that an enormous crater had been formed in the earth mass in front of the sheeting, or rather in front of where the sheeting had been.

This crater which was 7 feet deep, vertically, extended up to the baulks of the extra layer which roofed it in; its mean length was 10 feet 6 inches, and its mean breadth 9 feet 6 inches. In short, a fair sized chamber had been instantaneously formed in the heart of the earth mass by the powerful bursting charge of the steel shell (nearly 22 lbs. of powder). It was not at first evident where all the earth had gone to, as the amount thrown into the magazine (about 100 cubic feet) constituted only about one-sixth of the cubical contents of the crater, but a careful examination clearly showed that the clay had been compressed laterally, the sides being very dense and hard.

This shell had evidently passed under the front edge of the extra layer, and on exploding found a line of least resistance into the magazine, which it effectually destroyed.

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Rounds 8 and 9, pattern 'A' service cast-iron shells, struck top earth mass and exploded on the extra layer where it had been deprived of support underneath by the effects of round 6. These shells broke clean through the rails and baulks, opening a way from the outside into the magazine. 34 rails and a large number of fir baulks were broken by these two rounds. Rounds 13 and 15 hit the exterior crest and evidently penetrated to a great depth, as very little smoke came out of the tunnels they made.

They produced no effect that could be seen, but the whole mass of earth gave a perceptible heave upwards, when they burst after delay. They only contained 11 lbs. 5 ozs. of powder, being of "B" pattern, and hence, from being deeply buried, they acted as undercharged mines.

Round 16, pattern "B" cast-iron shell, penetrated on to the extra layer, where it was fully supported, broke clean through, and burst close underneath, forming a large crater.

This ended the experiment, in which the results obtained appeared to indicate that although the extra layer served to protect the overhead cover of the magazine, which apparently remained intact, it did not extend sufficiently far to the front to prevent a shell from penetrating to such a position in the earth mass that it had, on exploding, power to blow in the earth, in the line of least resistance which lay in the direction of the front side of the magazine.

The action of the delay fuzes was exceedingly good, only one shell seemed to be 'blind,' and in this case it is not unlikely that this sharp-pointed shell, having penetrated to great depth, the earth fell in behind it, and thus closed the tunnel and prevented the escape of any smoke.

Of the other 15 shells, 12 burst after delay, and three, on penetrating the extra layer of rails and baulks, without *appreciable* delay. It seems likely that the shock of striking the rails caused the slow-burning composition to crack up or fall in, and hence the usual delay did not take place.

Stowage of Powder in traversed recesses, below the ground level, with covering earth mass in front.

Recent experiments having shown that unless an enormous amount of material (such as heavy baulks and rails) be employed to strengthen the overhead cover of Field Magazines, it is difficult, if not impossible, to guard their contents from explosion (which is, indeed, liable to be effected by even a single, well-placed, 8-inch howitzer shell with delay-action fuze) this alternative method of stowing powder has been suggested, and would appear to have several points in its favour.

The system advocated consists of the distribution of the powder in a number of recesses, below the ground level, protected by a covering earth mass in front, and isolated one from the other by solid masses of undisturbed earth left between them. These excavations should naturally be as deep as circumstances would admit of, so as to obtain the maximum amount of cover, and it is obvious that, in any site where mined magazines could be employed, they could easily be made sufficiently so to secure ample protection for the powder.

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It is not urged for this system that it would either be practicable or advisable to employ it under *all* conditions, or that it secures absolute immunity from explosion, nevertheless, when adopted on level sites (devoid of striking features of ground, capable of being taken advantage of for purposes of cover), it would appear to possess the following advantages over ordinary field magazines, other than mined, viz. :—

1. Ease and rapidity in construction.

2. Little or no material required.[1]

3. By confining the result of a chance explosion to the powder contained in *one* recess it is unlikely that any pieces would be put out of action, whereas when a whole magazine goes up the results must be distinctly disastrous.

4. By keeping the covering earth mass *solid* it is probable that shells exploding in it would, for the most part, prove innocuous to the powder in rear, but when the earth mass is *hollow*, and the powder is stowed *inside it* (as in ordinary field magazines), shells exploding in the mass (being heavily tamped) are apt to find a line of least resistance in the direction of the magazine and blow it in.

The amount of powder that it would be advisable to stow in each recess would in great measure be dependent on the depth of the excavation below the ground level. As a general rule the recesses should be sunk as much as is consistent with efficient drainage and fairly easy supply of powder to the battery.

The powder being in M. L. cases (which are both air and water tight), it is hardly likely that the cartridges would run more, if as much, risk of deterioration from moisture as they would do in the damp and steamy interior of a field magazine.

Nothing but actual experiment can decide the amount of undisturbed earth necessary to secure effective isolation for the powder in the recesses, but it is well known that the explosive force of even large untamped charges of powder in the open is comparatively small.[2]

Series 12.

6-in. B.L. Gun 81 cwt.—Effect of common shells fired with low charges from medium B.L. guns at high angles of elevation in attacking concealed revetments or earth-works.

The 6-inch B.L. Mark II. on naval slide was the gun selected for this series, it being not unlikely that similar pieces might be disembarked from ships of war for use in the land attack of maritime fortresses, and that, under such circumstances, it might be desired to employ them for curved, or high-angle, as well as for direct fire. It

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1 If the covering earth mass be made with a revetted interior slope, gabions would be required for the purpose.

2 The results obtained in the 1885 experiments demonstrated the efficacy of this system of stowing powder. The shells fired failed to explode any of the powder, and when the powder in a filled recess was fired by electricity, the effect was confined to that particular recess, those adjacent on either side, remaining uninjured.

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was therefore sought in this experiment to determine the amount of accuracy obtainable in the curved fire of this piece under the following conditions:—

Range—1600 yards.

Targets—Wooden screen, 27 feet long by 18 feet high, for pattern on vertical target. Earthen parapet 30 feet thick, with exterior slope at 8° for effect on earth-works.

Projectile—Common shell, filled.

Bursting charge—6 lbs. 8 ozs. shell L.G. powder.

Fuze—Direct-action (quick).

Charge—6 lbs. R.L.G.[2]

Striking velocity—580 f.s.

Angle of descent—About 14°.

The first 10 rounds were fired plugged at the vertical wooden target, for pattern; the wind was rather strong and variable in force.

The result was:—

Over	3
Under	5
Hit	2
Total	10

Three of the shells struck just short, and hit the lower part of the target *en ricochet*. The shells appeared to be nearly steady in flight, and the few that showed slight instability, on leaving the muzzle, soon steadied themselves.

It appeared that although the line was good, the vertical dispersion was considerable; this is probably to be accounted for by the 6 lb. cartridge only occupying one seventh part of the chamber, which was made to take a 42 lb. charge, and hence the air space was unduly large.

The next 10 rounds were fired at a 30-foot parapet, with exterior slope at 8°. The first round was short, the next three over, and the remaining six hit the work.

Again it was noted that the line was good, but the vertical dispersion considerable.

The effect of the shells that entered the earthwork was decidedly small, for although none were deflected from their course, even when striking on the superior slope, the direct-action fuzes, at the low striking velocity, only allowed of such small penetration to point of burst that the mean size of the craters formed was only about 6 feet long by 4 feet 6 inches wide by 2 feet 3 inches deep.

The 6½ lbs. bursting charge was capable of giving larger results had the penetration to point of burst been better.

From the small number of rounds fired it would be rash to attempt to draw any very definite conclusions, but, as far as could be seen, it appeared that fairly good results might reasonably be expected from the employment of these pieces under the conditions named.

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Series 13.

Effect of gradual exterior slopes in deflecting projectiles on striking earthen parapets.

In this series exterior slopes of 15° and of 8° were fired at, the former both with the 8-inch howitzer and the 6-inch B.L. gun, and the latter with the 6-inch gun only.

It appears reasonable to infer that the more gradual the exterior slope (or the more 'glacis-like' its form) the greater the expenditure of ammunition necessary to effectually open up the work, for the following reasons:—

1. The tendency of very gradual slopes, when unbroken, to deflect the projectiles from their course and cause them to rise in the air before bursting.

2. The comparatively small amount of earth over the shells which do enter the slope at the moment of bursting.

3. The greater horizontal distance required to be cut through to form a breach.

8-inch R. M. L. Howitzer.—Experiments at Exterior Slope of 15°.

The parapet was of stiff clay, fairly dry and hard on the surface, and for some way in, but decidedly soft and plastic in the centre. The conditions of fire were as follows:—

Range—1200 yards.
Nature of fire—curved frontal.
Charge—maximum, 11½ lbs. R.L.G.²
Projectile—cast-iron common shell, filled, weight 180 lbs.
Bursting charge—14 lbs. (nearly) shell, L.G. powder.
Fuze—direct-action (quick fuze).
Angle of descent—4°.
Striking velocity—876 f.s.

Twenty rounds were fired with the following result:—

Under	1
Over	2
Defective in line	4
Effective	13
Total	20

The effect of the 13 effective rounds was to breach and open up the work fairly well. The amount of earth moved was 53·75 cubic yards.

The quick action of the fuzes, and comparatively low s.v. of the shells, only admitted of a penetration of about five feet to point of burst, and it could not be perceived that they were, in that short distance, appreciably deflected upwards from their course.

In the earlier stage of the breaching the amount of earth moved by individual shells was small, compared with what would have been blown away by similar shell fired into a parapet with an exterior slope at 45°.

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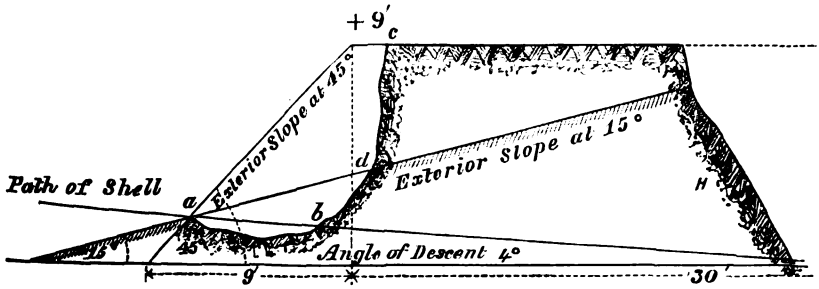
A reference to the diagram subjoined will show the cause of this.

The outlines show sections through parapets having exterior slopes of 45° and 15° respectively. In the case of a shell hitting, say two feet above the ground line, and penetrating five feet to point of burst; in the first instance, the shell entering at '*a*' bursts at '*b*,' and blows away the earth represented in section by the curve *a b c*; in the latter the shell only displaces the earth represented by the curve *a b d*, and this comparatively tardy destruction goes on until the main mass of the parapet under the superior slope is reached, after which the conditions are about the same in both cases. Thus we see that, in the earlier stages, the powerful bursting charges of the howitzer shells are, so to speak, in great measure thrown away, as the shells have never enough earth over them, at the moment of bursting, to enable them to do the work they are capable of, and hence there is a marked disproportion in the number of rounds required to breach the parapet in the two cases under consideration.

In previous experiments, the same piece, fired under like conditions, thoroughly breached similar parapets, with exterior slope at 45°, in from six to nine effective rounds; whereas with the 15° slope the work was not so completely opened up in 13 effective rounds.



6-inch B. L. Gun.

The same parapet having been repaired, was next fired at by the 6-inch B.L. gun, Mark II., under the following conditions :—

Range—1200 yards.
Nature of fire—direct frontal.
Charge—34 lbs., P^2.
Projectile—cast-iron common shell, filled, weight 100 lbs.
Bursting charge—6 lbs. 8 ozs. shell, L.G. powder.
Fuze—large percussion (quick).
Angle of descent—1 deg. 31 mins.
Striking velocity—1375 f. s.

Ten rounds were fired with the following results :—

Under	2
Effective	8 of which 2 were blind.
Total	10

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It may be as well here to explain the reason of the two blind shells being classed as effective. Owing to the high velocity, the striking energy is as high as 1,310 foot-tons, consequently a considerable amount of earth was displaced even by the blind shells.

The effect of these 8 rounds was to breach and open up the work fairly well. The amount of material displaced was 31 cubic yards.

Notwithstanding the quick action of the fuzes, the high-striking velocity enabled the shell to attain to a penetration to point of burst of from 12 feet to 18 feet, according as the clay was hard and undisturbed, or soft and loose. The shell on striking was not appreciably deflected upwards, and, from the first, burst *in* the slope. Thus, in round 2 (the first hit obtained) the shell penetrated 12 feet, burst and formed a crater 15 feet long;[1] greatest breadth 6 feet, greatest depth 3 feet.

6-inch B. L. Gun.—Experiments at Exterior Slope at 8°.

We now pass on to consider the effect of a *very* gradual exterior slope, viz., one of 8°, in increasing the resisting powers of a parapet. All the other conditions were precisely the same as those which obtained when the 6-inch gun was fired at the 15° slope. 23 rounds were fired.

The following is a *précis* of the results:—

Under	1	
Over	0	
Burst prematurely at gun	1	
Scooped up and burst in air	8[2]	hits, 21
" ricochetted blind.	2	
Broke up on impact	2	
Effective	9	
Total	23	

From this experiment it appeared that with so gradual a slope as 8°, and an angle of descent as low as 1 deg. 31 mins., as long as the slope where the projectiles strike is hard and undisturbed, they will be deflected upwards (after cutting a scoop) before bursting; and, furthermore, from the fact of the general inclination of the groove, or crater, ultimately cut through the parapet being so gradual, a not inconsiderable proportion of the shell will be deflected upwards in like manner, and burst in the air during the process of forming the breach.

Thus, in this experiment, we see only 9 rounds are classed as effective, although it must be borne in mind that the 8 which scooped up and burst in the air, and the 2 blind, cut away an appreciable amount of earth. For example, round 1 cut a scoop 12 feet long, 2 feet 6 inches wide, and 2 feet deep, and burst in the air, round 3 one 15 feet long, 3 feet wide, and 2 feet deep, and burst in the air, and so on.

At the conclusion of the experiment the parapet was found to be fairly breached. The amount of earth displaced was 45·5 cubic yards.

[1] The length includes the 12-foot long scoop cut by the shell to point of burst.

[2] Of this number 2 were deflected upwards by the exterior slope before it was cut up, and 6 by the gradually sloping groove or crater ultimately cut through the parapet.

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Précis of previous experiments.

The following are the results obtained in the Ordnance Committee experiments at Lydd in 1882 and 1883 with the same gun against a 30-foot clay parapet with exterior slope at 45° at the same range (1200 yards), the shells being fuzed with direct-action fuzes.

1882 EXPERIMENT.

Number of rounds fired			20
Result reported:—			
Under	3		
Over	1		
Hit { Blind, or broke up	12	16	
Hit { Burst	4		
Total	20		

Parapet was not cut through by 8 feet. Amount of earth displaced, 26 cubic yards.

In this experiment the gun was fired with a 42 lb. charge, instead of with a 34 lb. charge of P^2, as in the 1883 and 1884 experiments, consequently the striking velocity was 1552 f.s. instead of 1375 f.s.

This high striking velocity in the 1882 experiment was doubtless the cause of so many of the shell breaking up on impact.

1883 EXPERIMENT.

Number of rounds fired		15
Result reported:—		
Under	1	
Over	1	
Effective	13	
Total	15	

The majority of the shell were noted as having broken up on impact, but some burst at good penetration, and formed large craters in the clay, which, in this experiment was very wet and plastic; hence the parapet was cut through in the 15 rounds, and from 45 to 50 cubic yards of material were displaced.

From these two experiments it will be perceived how largely the results obtained are, in the case of clay parapets, affected by the state of the material, 20 rounds in one year's experiments doing far less than 15 in the next; at the same time it is right to bear in mind that the conditions of fire (as already pointed out) were not identical in the two experiments.

To sum up the results obtained in the three year's experiments (1882, 1883, 1884) it would appear, speaking generally, that howitzers are considerably less effective for breaching works with gradual slopes than they are for breaching works with steep slopes. The apparent causes for this have already been explained at page 17.

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Fire of high velocity guns at gradual slopes.

With high velocity guns, however, this does not appear to be the case, or at any rate, not in such a marked degree; to explain which we may, perhaps, not unreasonably, look to the following causes:—

1. The great accuracy of the gun enables shell after shell to be placed on the already cut-up portion of the slope, and hence to act with good effect.

2. The 'high velocity' cast-iron shell, ploughing along a gradual slope, lifts the earth over it as it goes, and consequently does not encounter such a measure of resistance as to lead to its breaking up; whereas when fired into 45° slopes, the majority of these shells break up from the resistance encountered.

Thus in the recent experiments, it was found that when the gradual slope was cut through, and the shells began to enter the heart of the parapet, a proportion of them broke up.

3. Again, when the shell power is comparatively small (as with the 6-inch gun), those projectiles that enter a 45° slope low down, and do not break up, but burst properly, are unable to lift the superincumbent mass of earth unless the clay is very soft and yielding, and are consequently more or less smothered, whereas those that enter a gradual slope have never more earth over them than they are capable of blowing away.

Hence it would appear that with cast-iron projectiles there are absolutely fewer rounds comparatively ineffective in the earlier stages of breaching parapets with gradual slopes than is the case in attacking works with steep slopes. With howitzer shells these remarks do not hold good, for they are neither liable to break up on impact nor to be smothered on bursting.

Considering the few data we have at present to go upon, it would be rash to do more than thus indicate the various causes which probably tend to influence the case. To enable really trustworthy conclusions to be drawn as to the advantages possessed by the gradual slope over one at 45° it would be necessary to carry out extensive comparative trials under precisely similar conditions, not only as regards ammunition, angle of descent, and striking velocity, but also as regards the material of the parapet, its solidity, and (in the case of clay) wetness or dryness. The interior of clay parapets is apt to be very wet, and when this is the case very large craters are made, and an unduly high estimate of the power of the gun will probably be formed.

In the 1884 experiments, the recently introduced 'large percussion' fuze was used for the first time in shells employed for breaching earthworks, and whether it is quicker or slower between impact and burst than the D.A. percussion fuze used in 1882 and 1883 experiments has not as yet been definitely determined, and, as is well known, the time the fuze takes to act exercises a very important influence on the results obtained.

It is more than probable that most common shell will shortly be

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made of *steel*, and will contain far heavier bursting charges than the present service cast-iron projectiles.

With such shells it is likely that for the reasons already given, there will be stronger cause than at present exists for modifying the usual form of exterior slopes.

SERIES 14.

Comparative effect of steel shell with various natures of bursting charges.

The object of this experiment was to obtain a direct comparison, under similar conditions, between the power of steel shells, filled with the ordinary bursting charge of shell L.G. powder, and similar projectiles filled with a mixture of pebble and pistol powder.

Reason of first firing the shells plugged.

Had the shells been fired, fuzed, into an earthen parapet, and burst in the ordinary way, such a comparison could not have been instituted because it would have been a matter of uncertainty as to whether the projectiles were, at the moment of burst, equally tamped in each case.

If, on the other hand, the shells had merely been exploded electrically after being buried at a certain depth, but without having been previously fired, the results produced would have been erroneous, owing to the different extent to which "setting back" (on discharge) mealing, caking, and consequently loss of explosive power takes place with the different natures of bursting charges experimented with.

It was therefore decided to first fire the shells plugged into an earthwork at what might be considered a medium range (1,200 yards), so as not only to get the setting back effect on discharge, but also the (presumed) setting forward effect on impact; then dig out and explode electrically in earth, under given conditions.

In carrying out the experiment some difficulties presented themselves, viz.:—

1. The uncertainty as to whether the shells supplied, which were about four calibres in length, would, on account of their great length, be sufficiently stable in flight to secure accurate shooting.

2. The known tendency of unfuzed projectiles fired from high velocity guns, and striking at a small angle of descent, to scoop up out of the parapet and fall far beyond the work, in this case into the sea.

With respect to (1) (stability in flight):—

In the 1883 experiments with steel shell some very accurate practice was made at 1,200 yards with the same gun with steel shell, four calibres in length, filled with discs of highly compressed powder, whereas in the series now under consideration the shooting was far from accurate, which may perhaps reasonably be accounted for as follows:—

Since the spiral of rifling (1 turn in 35 calibres) was found to impart stability in flight to 4-calibre shell on a previous occasion, the want of accuracy can hardly be attributed to insufficient rotation.

The position of the 'driving ring' is known to exercise an influence

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on the stability of a shell in flight, but it was in this case apparently of a similar kind, and at the same distance from the base of the shell, as the rings on the shells with which good practice was made last year; other causes have therefore to be sought for.

With regard to the position of the centre of gravity. It should, as far as is at present known, lie somewhat in front of the centre of the figure; as if in rear, a tendency to instability arises.

In this case the centre of gravity appeared to be well placed *before the shell were fired*, but it far from follows that it was so during flight for the following reasons:—

With a 4-calibre shell the long column of powder, which forms the bursting charge, is violently set back on discharge and highly compressed, especially in the case of shell L.G. powder, and this, it is urged, must cause an appreciable alteration in the position of the centre of gravity, in the direction of the base of the shell, for not only is the column of powder greatly decreased in length, but the densest portion lies at the base end.

With regard to the 4-calibre shells fired last year; from the fact of their being filled with powder, previously highly compressed under hydraulic pressure, it is improbable that any appreciable alteration in form, or distribution of the bursting charge took place on discharge, hence the position of their centre of gravity remained undisturbed.

With reference to (2) viz., the tendency of projectiles to be deflected upwards out of earth on striking at low angles of impact:—

It was sought to counteract this tendency, firstly, by firing at a portion of the parapet which had the exterior slope cut away till it was nearly vertical, and, secondly, to so lay the gun as to secure a point of impact close to the ground line, and thus obtain as much resistance as possible out of the earth mass.

The former expedient appeared to be in slight measure successful, but the latter could not, owing to want of accuracy in the shooting, be carried out.

It should be observed that the bursting charges of shell L.G. powder varied in weight from 8 to 9 lbs., and those of P. and pistol powder from 10 to 12¼ lbs.; these varying weights doubtless further detracted from the accuracy of fire.

The conditions of fire were as follows:—

Range—1,200 yards.

Target—30 feet earthen parapet.

Projectiles—cast steel shell filled with:—

1. Shell L.G. . . . .
2. P. and pistol mixed . } 10 of each nature.

Gun.	Charge.	Angle of		Velocity.	
		Elevation.	Descent.	Muzzle.	Striking.
				f. s.	f. s.
6-inch B. L., Mark II., 81 cwt.	34 lb. P².	1° 11′	1° 31′	1600	1375

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The results of the firing were as follows :—

Under	2	One fell in sea, after graze. One broke up on impact on striking the work, *en ricochet.*
Over	2	Fell in sea.
Hit, lodged	3	(2 not found).
Hit, rose and fell on shingle	5	
Hit, rose and went out to sea	7	(1 recovered at low water.)
Hit, and burst	1	
Total . .	20	

From this abstract it is seen that only seven shells were recovered for burying in earth and exploding electrically.

Effects of shell when exploded electrically.

With regard to the effects produced by the shells when exploded electrically in earth, it was found that :—

The shells filled with shell L.G. powder (about 9 lbs.) had not, with 6 feet of earth over them, sufficient power to make a clean crater. Two fired under these conditions formed craters only 4 feet and 2 feet 6 inches deep respectively, owing to the earth having fallen back. They displaced 4·68 and 2·93 cubic yards of earth respectively.

Three similar shells, buried 5 feet deep, formed clean craters 5 feet in depth, and displaced 10, 5, and 7 cubic yards respectively.

The shells filled with P. and pistol powder (11 lbs. 10 ozs.) had ample power to form clean craters when buried 6 feet; the two fired forming craters 6 feet in depth and displacing 13½ and 11½ cubic yards of earth.

From these results it would appear :—

1st. That similar shell take far larger bursting charges of P. and pistol powder than of shell L.G. powder, and produce far larger results; which is believed to be due, not only to the larger bursting charge, but also to there being less loss of explosive power from the mealing and caking of the bursting charge with P. and pistol than with shell L.G. powder.

2nd. That if shells which only contain about 9 lbs. of shell L.G. powder have more than 5 feet of earth over them at the moment of bursting, they are somewhat overmatched, and displace less earth than they do when acting at a smaller depth.

SERIES 15.

Number of rounds required to dismount a gun on an overbank carriage by frontal fire at 2,400 yards.

Effects of fire to be corrected by observations from firing battery and flanks only.

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In this series the conditions of fire were as follows :—

Ordnance.	Charge.	Angle of Descent.	Striking velocity.	Fuze.
		° ′	f. s.	
6-inch B. L. gun, Mark II.	34 lb. P.[2]	3 50	1150	D. A. and large percussion.
6·6-inch R. M. L. gun ...	25 lb. P.	5 38	892	D. A.
5-inch B. L. gun	16 lb. P.	4 16	1064	Small percussion.
8-inch R. M. L. howitzer...	11½ lb. R.L.G.[2]	9 12	809	D. A.

The projectiles used were common shell. The guns fired at were wooden dummies on wooden overbank carriages, which were placed in the two gun portions of a screened sunken siege battery of the ordinary type.

In the practice with the 6·6-inch R.M.L. gun, a pole showing over the screen indicated the position of the dummy gun, but as it was thought that this arrangement conferred undue advantage on the officer directing the fire, in the practice with the other three pieces the following plan was adopted :—

The officer on range duty held up (for a few seconds) from time to time a plank, or some such object, to afford such a transient indication to the firing battery as might reasonably be expected to be given by the smoke of one of the enemy's guns in a screened battery at the moment of firing. The officers observing the effect of fire were stationed, one just to the windward flank of the firing battery, the other in a position about 1,000 yards in front and 700 yards to the flank of the same. Each of these officers was furnished with a pivoted straight-edge fitted with sights, which he directed on to the aiming point when it was exhibited.

Correct *line* was thus obtained from the battery, the gun being laid approximately, in the first instance, on an auxiliary mark laid out in front, and the line being afterwards corrected by applying deflection, according as the point of impact was observed, by the officer looking over the sights of the straight-edge, to be to the right or left.

In like manner the officer observing (on the right flank) directed his sights on the temporarily-shown aiming-point ; then, as shell burst to the right or left of the fixed line thus obtained, he signalled over or under to the battery.

By this simple and easily applied expedient excellent results were obtained. Some such method of observing effects of fire is an absolute necessity when firing at an object concealed from view by an undulation of the ground or an artificial screen.

6-inch B.L. gun.

The results of the practice were as follows :—

Over	3
Under	8
Hit battery	12
Total	23

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The gun in No. 1 gun portion was dismounted by a direct hit—the 12th round.

That in No. 2 gun portion by a shell bursting in the scoop—the 22nd round.

It is uncertain whether, under the latter circumstances, a real gun would have been dismounted or not.

Two of the shell were noisy in flight, and it was thought that the driving ring came off—both struck considerably short.

6·6-inch R.M.L. gun—23 rounds.

This gun was mounted on a Moncrieff hydro-pneumatic carriage, with oil in the cylinder instead of glycerine and water, which was found to give rise to rapid corrosion. The mixture of oil used in this trial consisted of two parts paraffin to one of olive oil. The air pressures were the same as had been used with glycerine and water in the cylinder viz. :—gun down 700 lbs., and gun up 400 lbs., to the square inch. The very permeating nature of paraffin oil caused it to be forced somewhat freely through the "U" leather at the neck of the cylinder, thereby occasioning a proportionate loss of air pressure. A somewhat thicker and more viscid oil would probably be found to give better results—

The results of the fire were as follows :—

Under	8
Over	11
Hit	4
Total	23

Of the four shells that hit the battery, one, the 20th round, grazed on the superior slope, struck, and dismounted the dummy gun *en ricochet.*

5-inch B.L. gun—25 rounds.

The results of the fire for dismounting purposes with this piece were as follows :—

Under	10
Over	4
Hit	11
Total	25

Of the 11 shells which hit the battery, round 17 dismounted No. 1 dummy gun by a direct hit, and round 20 burst on the superior slope, a splinter of the shell knocking the left trunnion off dummy gun No. 2. It is uncertain whether this shell would have dismounted a real gun.

8-inch R.M.L. howitzer—23 rounds.

Twenty-three rounds were fired with the following results :—

Under	12
Over	1
Defective in line	1
Hits	9
Total	23

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In this practice the observing officers were not in possession of proper straight-edges fitted with sights, consequently their observations were not always correct, which led to incorrect elevation being given in some instances. The dummy gun was dismounted by the 22nd round; the shell struck the superior slope 8 feet short and 3 feet right, the force of explosion blowing off the chase of the gun.

It is hardly likely that this round would have dismounted a real gun.

The results obtained in this series warrant the belief that, with an observing party properly posted (*i.e.*, well forward, well on the flank, and if possible in a somewhat elevated position) it is quite practicable to deliver an effective fire at an object concealed from view, provided the observing officers are furnished with suitable instruments, and that the smoke of the gun fired at can be seen when, or shortly after, it leaves the muzzle; of course if it has drifted some distance before it is seen, more or less uncertainty as to line and range must prevail, and tend to detract from the accuracy of fire.

Concluding Remarks.

In conclusion, it would perhaps be as well to call attention to the fact that the earthworks fired at in the experiments of 1882, 1883, and 1884 have *all* been made of the alluvial deposit found on the Holmstone range, and which may be termed a fairly stiff clay; hard when dry, and when thoroughly wet of the consistency of cheese. It is of course desirable to ascertain the effect of Artillery fire on *all* natures of soils varying between pure sand and stiff clay, and it is to be hoped that in due course opportunity of so doing may be secured.

The heavy labour and expense of bringing sand or loam from other sites on to the Holmstone range, coupled with the fact of the ground having only this year become Government property, has hitherto intervened to prevent any steps being taken in the direction indicated.

Considering the many cases that might occur on service of works thrown up on alluvial sites, the various results obtained in these experiments necessarily possess considerable interest and value, and throw much light on the powers of resistance to Artillery fire of the various works fired at when constructed of *clay*; which should, however, be recognised as the nature of soil least suited for the purpose, pure sand being taken as affording the *highest* powers of resistance, and light loam being probably a fair average between sand and clay.

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CAVALRY.

A REVIEW:

BY

CAPTAIN J. M. GRIERSON, R.A.

Militärische Briefe. I. Ueber Kavallerie;

VON

KRAFT, PRINZ ZU HOHENLOHE-INGELFINGEN.

To THOROUGHLY appreciate Prince Kraft's letters upon Cavalry, they should be read before those upon Artillery and Infantry, as, as the author himself states, he takes more a bird's-eye view of cavalry matters, and the letters are consequently wanting in that strong element of personal experience, and also in that enthusiasm for his own branch of the service, which are such distinguishing features, and which form so great a charm in that work which may be looked upon as a golden book for gunners—the "Letters upon Artillery." Still, Prince Kraft for seven years commanded a Division of all arms, and had constantly to conduct detailed inspections of cavalry, and this fact alone, independently of his great experience in war, gives him every right to be heard on the subject. And all the more welcome should Prince Kraft's work on cavalry be to the Artillery Officers of the world, as it gives one more proof—if more be required—that, given practical experience in working with other arms, there is nothing to prevent Artillery Officers commanding, and intelligently commanding, bodies of troops of all arms, and that without laying themselves open to the imputation of exalting their own arm at the expense of others. In

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no army has this keeping in the background of Artillery Officers been more pronounced than in the Prussian, in which, as stated by a writer in the *Allgemeine-Militär-Zeitung* of 3rd April, 1886, in a long career he can only call to mind two Artillery Officers who have commanded mixed Divisions, and in which at present, as far as we can make out, not one Artillery General commands an Army-Corps. Prince Kraft has shown the falseness of this system, and the thanks of the Artillery in general are due to him for it.

In the first eight letters, the Prince reviews the conduct of the German Cavalry in the three campaigns in which he has taken part, and points out that the best results have been attained when the cavalry worked in complete harmony with the infantry—the principal Arm always—and subordinated its action to that of the latter. As neither of the three arms can work independently, cavalry, therefore, may be said to have had as much share in the successes of those wars as the other arms, only its field of action has been curtailed by the the precision of modern fire-arms, which limit the sphere of activity of the horsemen to such objects as can be attained by their speed. In many cases in those wars the action of cavalry was limited by other causes. In the Franco-German War, a successful pursuit was seldom made after a battle by the German cavalry, but many critics seem to forget that when the retreat of a defeated army is covered by fortresses, a direct pursuit is impossible, as no one has yet presumed cavalry to be capable of taking such unaided, and in the latter battles of the campaign, the frozen state of the roads made cavalry action next to impossible.

Putting aside the isolated cases of action on the battle-field, the principal part of the renown gained by the German cavalry in the war of 1870–1, was due to the admirable manner in which it performed the screening and scouting service in front of the army, and the Official account speaks of "the clear, reliable reports of the numerous German cavalry, upon which decisive action was taken by the Head-Quarter's Staff." The name "Reserve Cavalry" had been done away with, as, in the case of the Artillery, it naturally led to false conclusions as to its use, and the cavalry, not incorporated in the Infantry Divisions, was organised in independent Cavalry Divisions, which covered the front with an impenetrable veil, spied out the movements of the enemy, and enabled the columns of its own army to move in comfort and safety. At first, indeed, the German cavalry seemed to have some doubts as to its proper functions, and the retention of the 4th Cavalry Division in rear of the III. Army on the 6th August, and the consequent loss of touch of MacMahon's army have been severely criticised, but Prince Kraft points out that the Germans were then in ignorance of what masses of troops were in rear of the 1st French Corps, and hesitated to risk a Cavalry Division far to the front. Mistake or no mistake, however, the German cavalry nobly redeemed its reputation on subsequent occasions, and its rapid advance to the Moselle, and the consequent paralyzation of the French plan of operations, contributed not a little to the success of the German operations.

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On the battle-field, too, the German troopers showed themselves in no whit inferior to their forefathers of the Seven Years' War, although here also critics have had their faults to find. Almost universally, Bredow is blamed for having charged at Mars-la-Tour without a support. The check suffered by the French would undoubtedly have been greater had he been followed by such a body, but, as a matter of fact, none such were available. Time was precious, the situation was critical, Bredow had to be devoted to destruction to save the army, and it was only with the greatest difficulty that a single Cavalry Regiment, the 11th Hussars, was got together to rally the remnant of his Brigade, as the whole of the remaining 68 squadrons then with the army were employed in guarding the flanks of, or acting as support to, the hard-pressed Infantry, then extended in one long, thin line. And after all, at what price was the success gained? Only 409 horses were offered up to save the centre of the army! Again, the 1st Guard Dragoons, by the loss of 250 horses, saved an entire (Wedell's) Brigade! Surely such losses were not out of proportion to the results attained.

To the Divisional Cavalry, Prince Kraft also gives their share of praise, and speaks of the glad feeling he experienced when at St. Privat his guns came into positions to attack St. Marie aux Chênes, their left flank, towards St. Ail, being exposed apparently to the attack of French infantrymen issuing from St. Marie, and when, on riding forward, he found the whole of the Guard Hussars drawn up in a hollow between his guns and the enemy, and only awaiting a chance to be at the latter. Many examples, says the Prince, might be adduced of the enormous services rendered by the patrols of the Divisional Cavalry on the field of battle. Those brave horsemen rode up to the enemy's position, and brought back sure and reliable reports of his numbers and dispositions.

Next, perhaps, to the advantage gained by German Head-Quarters by the reliable information brought them by their cavalry of the enemy's movements, may be placed the advantage gained by the German infantry in their strength being spared by the cavalry screen. The worst cantonment is better than the best bivouac, and, protected by their Cavalry Divisions, the infantry columns could rest in peace and comfort in cantonments, without fear of night alarms. Even when in such close contact with the enemy as on the 28th August, the entire Prussian Guard Corps, trusting in their advanced Cavalry, were placed in cantonments.

Before 1866, many voices were raised to prove that rifled fire-arms had driven cavalry off the battle field, but Custozza, Königgrätz (attack of the 1st Squadron, 10th Prussian Hussars), and Mars-la-Tour would serve to show that Cavalry well-handled, and with a leader who knows how to seize his opportunity can still have a word to say in the result. Wörth, Vionville (charge of the French Guard Cuirassiers), and Sedan, are examples on the other hand of how not to do it. In future, therefore, we may still expect to see cavalry—aye, and masses of cavalry—on the battle-field. Their action will usually be from the flanks, as by attacks from the centre of the line they mask the fire of

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their own side. Prince Kraft tells how the 6th Prussian Division was just beginning to retire before the fearful fire from the French positions round Vionville, when suddenly this fire ceased. The Prussians at once halted, amazed at their escape, and discovered the cause to be the attack of the French Guard Cuirassiers! This they soon disposed of, but the momentary relief from the heavy fire was all they required to enable them to hold their position. Cavalry will often in action have chances of approaching unhurt to troops engaged with their own side—*e.g.*, a hostile artillery mass engaged with their own infantry and artillery—and such are very favorable if the ground permits of any thing like a covered approach.

In general, in future, cavalry action will be much the same as in the war of 1870—at least it will be conducted on much the same principles, for no country can again hope to have the good fortune of the Germans to be opposed by a cavalry unworthy of the name in all but personal gallantry. The Cavalry Divisions will be pushed one to three days' march to the front of the army, but will in future be much more independent on account of the general introduction of rifled carbines, and the larger number of guns attached to each. Whether, however, the Russians have done wisely in changing *all* their cavalry into Dragoons, armed with rifle and bayonet, remains to be seen.

In the 9th and 10th Letters, Prince Kraft considers the question of cavalry raids, and first replies to the critics who blame the German cavalry for not having made such in 1870. There is much that is poetical, much that is enchanting about the idea of a cavalry raid, but from the sublime to the ridiculous is only a step, and when the question comes to be examined practically, such would appear to have been next to impossible, and at all events too costly. The principal period in which, say the critics, raids should have been made by the German cavalry was that when the new armies were being formed by Gambetta. The laying waste of large tracts of country being put out of the question by the conditions of modern civilized warfare, there only remain two classes of raids to be dealt with, those with a general roving commission and those with a distinct object. Had a German Cavalry Division been pushed among Gambetta's armies, with a general order to impede mobilization, it would doubtless have cut off a large number of stragglers, broken up a Battalion or two, and frightened a few old women of both sexes, but once it came upon a formed body of troops, it must at once have given way. A Division of 6 Regiments could only put 1400 carbines into the shooting line, and in a difficult, cut-up country like that round Orleans, Rouen, &c., what chance would those have had against even a Battalion of Infantry decently well posted? Would the loss of a Cavalry Division have been equivalent to the damage then done? There only remain raids against certain objects, such as important centres of mobilization (Bourges, Le Mans) or the seat of government (Tours). But these were far distant, the approach of the Cavalry would have been announced by telegraph, and troops gathered, both sufficient for their defence against the small force of a Cavalry Division, and to cut off the retreat of the detachment. A

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Cavalry Division undertaking a raid to such a distance would have to be accompanied by a certain amount of trains, and such a body could not save itself across country, nor cross rivers with its guns, &c. Such a raid was actually attempted by the 4th Cavalry Division on the 25th September, but at Chevilly it was met by Infantry and had to retire with loss. As the official account says, "an isolated advance of a mass of Cavalry in this difficult country appeared unadvisable," and the Division had to return to Toury and Pithiviers. As a matter of fact, numerous as were the German horsemen, none could be spared for such dare-devil ventures, and all were required to watch the French armies which were advancing against the weak forces covering the siege of Paris, whose only hope of success lay in good information and rapid concentration.

Passing now to the future, the raids in the earlier period of mobilization, about which so much has lately been written, appear to Prince Kraft to be open to precisely the same objections as those stated above. It appears to be forgotten that the conditions obtaining in America during the Civil Wars are not likely to be repeated in European warfare. Firstly, the whole country was not hostile, and in every village a raiding party could count on finding sympathizers, if not friends. Their supplies would therefore be assured, and their wounded and sick cared for. In addition, the extensive woods allowed of movements for long distances being made unobserved, a condition which is totally wanting in Europe, thickly populated and well provided with communications as most parts are. Such raids would only therefore succeed in cutting off isolated men hastening to join the colours, or at the most breaking up a Battalion or two. The important points, large cities, detraining stations, &c., would generally be protected by troops; and even against a few Infantry, what could an isolated body of 2000 horsemen far from supports hope to effect? No, says Prince Kraft; better to keep the Cavalry Divisions for the real work of war, and confine such raids to small patrols sent to destroy railways, break telegraph lines, &c., as was done by the German Cavalry in 1870—a work which can equally well be done by small parties, whose loss will not be felt, who are more mobile, who are better able to support and conceal themselves, and who therefore are more likely to succeed than large masses.

Passing now from strategical and tactical questions to those of more purely Cavalry interest, in his 11th Letter the author points out the difficulties which Cavalry Officers have to contend with. Increased demands have lately been made upon Cavalry, long distances must now be traversed at the quickest pace, patrols are sent out to hitherto unheard of distances, musketry instruction is imperative, every horse must now leave the ranks at its rider's will, and carry him straight across country, and all this involves an enormous increase of the Cavalry Officer's work. The difficulty is to discover the *juste milieu* to which the instruction may be carried, for a surfeit of work is apt to render both men and horses languid, and to tax their strength too far. And it is not only in the matter of instruction that the Cavalry Officer has his difficulties to contend with. The drill of his arm is necessarily

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now so quick that his mind must be made up at once, and his decisions taken with hardly a moment's consideration. In the Infantry a wrong order can be cancelled, a mistaken movement corrected, but in the Cavalry, never. Once the squadrons launched, the control passes out of the hands of the Commander and into those of the inferior leaders, and the pace, the noise, and the dust prevent all correction. Thus, a Cavalry Officer's reputation, aye, his honour, hangs often by a single silken thread—on a single thought—on a single order! To the above may be added, *par parenthèse*, that a Cavalry Officer undergoes much more bodily exertion than his brother in the Infantry, and that his pocket is more heavily touched.

As to the performance to be expected from the Cavalry of the present day, Prince Kraft lays down in his 12th Letter that a squadron must be able to traverse a German mile (7½ kilomètres) at a quick pace (trot and gallop) and must be able to make an attack at the end of it, that selected horses must be able to traverse 80 to 100 kilomètres in a day, such as would be required from them when forming part of Officers' patrols, that the Officers destined to lead such patrols should be so prepared as to be able to make such reports on the enemy and on the country as would enable Head Quarters to base their plans upon them, and that masses of cavalry should be able to march 45 to 50 kilomètres a day for three days in succession. The first three points are already provided for in the programme of instruction of the German Cavalry, but the last is a point to which little attention has as yet been paid. And yet a great deal of practice is necessary to ensure the proper execution of such marches. First, practice is required in the choice of *rendezvous*. Nothing tires cavalry more than long waiting on horseback, and therefore the body to rendezvous at one point should be as small as possible, and all measures should be taken to enable the various units to dovetail in to the line of march, or to move off in proper time on parallel roads. Secondly, practice is required in giving precise and clear orders from the saddle, forgetting nothing, especially in the matter of letting scouts and advanced guards get a certain distance in front. Lastly, excessive care is required in choosing the pace at which columns are to move. From experience, Prince Kraft recommends, as an example, on a march of 50 kilomètres, first half-an-hour's walk, then, in succession, half a (German) mile's trot, half-an-hour's walk, a (German) mile's trot, half-an-hour's trot, and half-an-hour's walk, which makes in all, including a halt of half-an-hour, four (German) miles, or 30 kilomètres in 3 to 4 hours. A halt of 2 to 3 hours should then follow, during which the horses should be watered and fed, and the men should have a meal, after which the remaining 20 kilomètres may be traversed in three hours. Thus the whole march should take at the outside 10 hours, a space of time not too great for a forced march. To practice such movements in peace, Prince Kraft recommends manœuvres of two Cavalry Divisions placed 5 marches apart. Each could advance for two days driving a marked enemy before it, and on the third day the Divisions could manœuvre against one another. A day of rest should then follow, then two day's of manœuvres, then a day of rest, and then the

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Divisions should each retire on their own districts before a marked enemy, the whole exercise thus lasting ten days. Far from separating the cavalry manœuvres from those of the infantry, Prince Kraft considers that it is of the utmost importance that the cavalry should take part in the manœuvres of all arms, and that the exercises sketched above should take place after the grand manœuvres, the extra expense caused by the cavalry recruits being kept ten days longer with the standards than those of the infantry with the colours being infinitesimal compared with the advantages gained.

The 13th (detail instruction), 14th (squadron training), 15th (field service) and 16th (drill in large bodies) Letters apply more particularly to the German Cavalry, and before entering upon these matters, Prince Kraft apologizes for abandoning his bird's-eye attitude and descending to matters of detail, but excuses himself by saying that in his seven years' experience as a Divisional Commander he has noticed many such matters in his inspections and will only mention the results he has observed to be attained by different methods. With one exception, we do not propose to enter into the detail of those letters, firstly, because they apply more specially to cavalry matters, pure and simple, and secondly, because we observe that a large number of Prince Kraft's suggestions, especially in letters 15 and 16, have been adopted in the new German Cavalry Regulations of 10th April, 1886. The one exception is the mode of inspecting a squadron, instead of ordering a squadron to be ready for inspection, formed up on the drill ground, in which case it was certain to be there before the time fixed, thereby wearying the men and horses, and losing time, Prince Kraft's method was to order the men to be standing to their horses in stables ready to turn out. He inspected them there, and then ordered the turn out. Directly the squadron was formed up, he again inspected it, and on the march to the drill ground, advanced guards, &c., were practised, thus leaving all the time actually on the drill ground free for drill. If two squadrons were inspected together, one retired before the other to the drill ground, and generally manœuvred against it when on the latter. To Cavalry Officers, these four letters must be particularly interesting, and to British Cavalry Officers—after their own admirable regulations have, as the Germans say, "gone over into their flesh and blood"—we might add that many useful hints will be found in the regulations quoted above.

The 17th letter deals with the question of whether permanent Cavalry Divisions should be organized in peace, and of such a course, the author pronounces himself a decided opponent. In war, there are two positions in which a Cavalry Regiment might find itself, as the Regiment attached to an Infantry Division, or as part of a Brigade in an independent Cavalry Division. To make the peace organization correspond with the order of battle in war, Divisional Cavalry would have to be organized in peace, and hence would ensue a separation into two parts of the Cavalry, which could not fail to be detrimental to those Regiments detailed as Divisional Cavalry. The duties of all Cavalry Regiments are the same, within their own spheres, in war, and

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therefore their training should be perfectly uniform in peace. A further objection in Germany to the formation of independent Cavalry Divisions in peace is that only two Corps (the Guard and 15th) have eight Cavalry Regiments, the others having from four to six. If two Divisional Cavalry Regiments were told off to each Army Corps, the remaining Regiments of two or more Corps would have to be united to make up Cavalry Divisions of six Regiments, thus breaking up the strictly territorial system on which the German army organization is based. To this objection, some writers have proposed that the Cavalry Divisions should be disassociated from the Army Corps, and placed under a special Inspector General, but this, the Prince points out, would tend to weaken that close bond of union which should exist between all arms of the service, and he remarks that it is curious that while the Field Artillery are doing their utmost to strengthen the ties between themselves and the rest of the army, the Cavalry should aspire to separation. He therefore considers the present organization the best, and holds that although on mobilization Cavalry Divisions meet for the first time, in a few days all settle down into their places, and that with a perfectly uniform system of training there should be no friction.

The Prince has some interesting remarks to make in the next letter on the subject of cavalry working with infantry, and his opinion of the great advantage gained by the infantry and artillery in having the Divisional cavalry so intimately associated with them on the field of battle has been recorded above. Infantry is the principal arm—*die Hauptwaffe*—and therefore the Cavalry should have to make its action fit in with and aid that of the Infantry. For this purpose, all the Cavalry of an Army Corps should invariably take part in the Corps or Divisional manœuvres, the special cavalry manœuvres recommended by the Prince taking place *after* the manœuvres of all arms. The remarks made as to "putting troops out of action" in manœuvres are full of practical sense. No good is gained by making cavalry dismount and consider themselves *hors de combat* for a longer or shorter period. All ranks feel it as a disgrace, and if Cavalry are always to be put out of action on charging Infantry, as generally happens, they will soon get to think that such attacks are impossible and the "*Reitergeist*" will be impaired. Therefore, says the Prince, the less putting out of action there is the better, and it is better to adjudge neither side as victors, but to make both retire. The only exception should be when one side has committed a fault such as letting itself be surprised, and in this case putting out of action is a punishment.

The author is no great friend to cavalry fighting on foot. He shows that in a Cavalry Division of 24 squadrons of 60 files, the Cuirassier Regiment would probably be kept as a mounted reserve, as the idea of a cuirassier with his armour and jack boots crawling on his belly through a potato field is slightly ridiculous, while two squadrons of a light regiment would be retained as mounted scouts. There would remain 18 Squadrons, which would give about 80 dismounted men each, or a total of 1440, provided with 20 rounds of

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ammunition each. Now, what could such a force effect? A battalion of 700 or 800 well posted infantry would probably cause them enormous loss—such loss as to render the Division useless—and would certainly repulse the attack. Far better, says the Prince, to manœuvre on horseback, gain the flanks and rear of the enemy, and so paralyze his action. The offensive action on foot of an entire Cavalry Division is therefore, the author thinks, a case which will seldom or never occur, and the only probable cases of cavalry acting in this manner will be when it is necessary to drive off bands of armed inhabitants, *francs tireurs*, or small bodies of troops. On the defensive, however, the case is different, and as examples of the services cavalry may render in this event, Prince Kraft cites the defence of the Kaninchenberg at Forbach by Dulac's Dragoons, and the holding of Dieulouard by the Prussian Guard Dragoons against French Infantry.

The 20th and last letter is devoted to the question of the proportion of Horse Artillery to be attached to a Cavalry Division, and the remarks made, are not applicable all round, on account of the difference of our organization, to British circumstances. At first it would appear that one battery would suffice for a Cavalry Division, but as a Division may be broken up into Brigades, it is evident that more than one battery should be provided. No arm, says Prince Kraft, more requires the constant presence of the (Company, Squadron, or) Battery Commander than the artillery. Now, the place of the Officer Commanding the Artillery attached to a cavalry force is with the Commander of that force, so that he may at once be made acquainted with his designs, and take his own measures for supporting them. If he is also a battery commander he cannot therefore be with his battery. The proper force of Horse Artillery to have with a Cavalry Division is therefore an *Abtheilung* (3 Batteries) commanded by a Field Officer, who has an Adjutant. This force may seem excessive, but often detached Brigades have to be provided with Batteries, and it must be remembered that on the day of battle the Batteries of the Cavalry Divisions join the nearest masses of guns. Other causes also plead for Horse Artillery *Abtheilungen* taking the field as a body. No other arm of the service is broken up on mobilization. No Cavalry Regiment detaches one squadron to another Army Corps or Division, and why should Horse Artillery detach batteries? Each *Abtheilung* has also a Paymaster, and how can he look after the accounts of a detached Battery? All these reasons seem to claim that an *Abtheilung* should take the field complete. There is one more reason why this should be the case. Experience has proved that, if a battery is detached and has no officer of standing at Divisional Head Quarters to represent its interests, &c., it gets a scant share of the decorations and rewards which fall to the lot of its better represented comrades of other arms. It may be the fashion to affect to despise decorations and orders, and to say that the knowledge of having done his duty should be enough for any soldier, but as a matter of fact men like some recognition of their duty having been well performed, and the prospect of a decoration is a great incentive to extra exertion. A battery without a representative on the Staff of a Division is in great

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danger of being, unintentionally of course, overlooked, and nothing is more galling to soldiers, who after all are human beings, and, as such, capable of feeling, than the consciousness of their services, which they know to have been good, being overlooked for want of proper representation. Therefore, says the author, an Artillery Officer is required on the Staff of a Division in a position to make his voice heard.

Verily, Prince Kraft understands men, and his words are golden.

ALDERSHOT,
July, 1886.

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OLD AND RARE BOOKS

IN THE

R. A. LIBRARY.

REPRINTED FROM NOTES ISSUED WITH No. 9, VOL. XII., AND NOS. 6 AND 7, VOL. XIII.

COMMUNICATED BY

THE SECRETARY.

DURING an overhauling of the Regimental Library, lately made by the Secretary, Capt. K. Stephenson, R.H.A., with a view to re-cataloguing it, some curious and rare books came to light.

One of the most ancient of them, and in some ways the most curious, is entitled :—"Lectura super quarto Decretalium," by Antonius de Butrio : Rome, 1474. "Decretals, in Canon Law, are the answers sent by the Pope to applications made to him as head of the Church, chiefly by Bishops . . . . for guidance in cases involving points of doctrine ; or discipline. In the early days of the Church, these replies came to be circulated throughout the various Dioceses, and furnished precedents to be observed in analogous circumstances." [Encyclopædia Britannica, 9th Ed., Art. "Decretals."] In the 15th century a collection of 73 "Decretals," 1298-1484, under the title "Extravagantes Communes," was published, according to the traditional scheme, in five books, "sed vacat liber quartus," devoted in previous compilations to the law of marriage. I speak with all reserve of the contents of our ancient volume, not having spent my life in the study of mediæval Latin. But a glance at it will prove to anyone possessing the least smattering of Latin that it is on a delicate subject—the relation of the sexes. It probably, therefore, has some connexion with the "liber quartus" in question. I am not prepared to say that, if translated, it would escape the operation of Lord Campbell's Act. But it is comparatively safe in mediæval Latin, a subject not taught at the Academy. How such a book found its way into a Military Library, is a mystery.

Another is a description of a new experimental Bombarde or Hand Mortar, made for Frederick, Prince of Wales, father of George III. It is a German MS., by Colonel Seebach, and is illustrated with 59 admirable pen-and-ink sketches of a soldier with his bombarde in various positions.

On the title-page of "Descriptions et brève déclaration des Règles Générales de la Fortification, par Henry Hondius," is found the autograph, "Menno Cohorn, Leúwarden, 1684 :—that of the celebrated Engineer.

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The title-page of a fourth is adorned with the autograph of even a greater man,—"William R."—William III. This work is the "Fortifications du Comte de Pagan; Paris, 1645."

The Library possesses another book that once belonged to William III. It is called "A New System of Mathematics, composed by the eminently worthy Sir Jonas Moore, Knight, Surveyor General of His Majesty's Ordnance, and Fellow of the Royal Society, &c. This book was a presentation copy to the King, and afterwards presented by him to the Duke of Ormond of 1689.

Sir Jonas Moore was a celebrated mathematician, 1617–1679. He was Tutor to Prince James, afterwards James II. He founded the Mathematical School of Christ's Hospital. He was buried at the Tower, and guns equal to the number of years of his age were fired at his funeral. His son was knighted by King James, and the reversion of the post of Surveyor General of the Ordnance was confirmed on him. "Nevertheless" Aubrey adds, "young Sir Jonas, when he is old, will never be old Sir Jonas, for all the Gazette's Eulogies."

Again there is a very curious book entitled:—"Lawes and Ordnances of Warre," established for the better conduct of the Service in the northern parts, by His Excellence the Earl of Northumberland, Lord General of His Majesty's Armies and Fleet: London, Robert Barker, 1640. This book is magnificently bound in white vellum, with gold adornments.

A seventh work is Euclid, in Arabic:—"Nunc primum Arabicé impressi." A MS. note on the title-page speaks of this "editio splendida, sed maxime rara," signed J. Baptista Raijmundus. This was Raimondi, appointed Controller of a printing press at Rome in 1580, by Cardinal Medici, afterwards Grand Duke of Florence. The object of this printing establishment was to supply scientific and other information to the Oriental converts.

Not the least interesting of these old books is the first original English work on the art of war:—

OF THE KNOWLEDGE
and Conduct of Warres, two Bookes
latelye wrytten and set foorth, profitable for such as delight in Hystoryes, or martyall affayres,
and necessarye for
this present
tyme.

[*Anonymous.*]

RICHARD TOTTILL,
7 June, 1578.
[*No place.*]

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The following extract will show how highly steadiness of character and moral excellence were valued in the pre-Armada times:—

"The Souldiour . . . ought to be affected and enclyned unto vertue, no lesse than the Captaine, yet is it in an other sorte, for the difference of their places, functions, and doings . . . . The Souldiour ought, in like sorte, to be a cyvill manne, to feare God, and live orderlie in his degree, as it behooveth the Captaine, beinge in daylie daungers of deathe, which are alwayes lesse feared of him which hath an honest and well prepared minde, voide of the horrour and burthen of lewde and dissolute dealings, liynge upon his conscience." —Chap. 10., Fol. 19. [*Not paged.*]

The following Notes on curious and valuable books, brought to light in the recent re-arrangement of the R.A. Regimental Library, Woolwich, have been compiled by Lieut. F. L. Nathan, R.A., Secretary, R.A. Library.

Probably the most valuable and interesting book in the Library, is the Atlas of the Blaeu's. This Atlas consists of eight folio volumes. Volumes 1 to 6 constitute the "Theatrum Orbis Terrarum sive Atlas Novus," and were published at Amsterdam between the years 1648 and 1655; they are as follows:—

Volume	I.	Europa, Germania, 1649–55.
Volume	II.	Gallia, Hispania, Asia, Africa, America, 1655.
Volume	III.	Italia, Graccia, 1655.
Volume	IV.	Britannia, 1648.
Volume	V.	Scotia, Hibernia, 1654.
Volume	VI.	Sina et Japonia, sive Novus Atlas, sinensis a Martino, Martinio soc Jesu descriptus, 1655.

The present example of Volume V. is believed to be *unique*, as it contains a highly illuminated sub-title, dedicated to Oliver Cromwell, shortly after his assumption of the Protectorate. This dedication is surmounted by Oliver Cromwell's coat-of-arms, and is as follows:—

OLIVARIO,
DOMINI PROTECTORI,
REIPUBLICÆ,
ANGLIÆ, SCOTIÆ,
ET HIBERNIÆ.

The maps were engraved, from the first survey of Scotland, by Timothy Pont and others, the original draughts of which after being sent over to Holland for engraving, were deposited in the Advocate's Library, Edinburgh, *vide* Gough's "British Topography," Vol. 2.

The bibliography of this rare edition of the Theatrum is very obscure, and known to but few, and almost forgotten by Bibliographers. Volumes I. and II. were first published by Joannes Blaeu the elder in 1638, the title page being afterwards altered by his two sons as above.

The remaining two volumes are the "Novum ac Magnum Theatrum Urbium Belgicæ, Regiæ et Foederatæ ad praesentis temporis faciem expressum, a Joanne Blaeu. Amstelædamensi, 1649." This is a presentation copy, previous to pagination, with dedication to Philip IV. of Spain, signed, Joannes Blaeu, Guilielmi Filius, printed in Gold.

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This dedication page is as follows :—

SERENISSIMO,
POTENTISSIMO,
PHILIPO,
QUARTO,
PACIFICO,
HISPANIARUM
INDIARUMQUE, &c.
REGI CATHOLICO,
PIISSIMO ;
BURGUNDIONUM, &c.
PRINCIPI,
FELICISSIMO ;
VICTORI
AC
TRIUMPHATORI,
AUGUSTISSIMO ;
THEATRUM URBIUM
BELGICÆ,
REGALIS,
MULTO LABORE, ÆRE MULTO
A SE COLLECTUM,
IN PERPETUI CULTUS MONUMENTUM
DAT, DICAT, DEDICAT.
JOANNES BLAEU,
GUILIELMI FILIUS,
AMSTELÆDAMENSIS.

Volume I. Belgiæ Regiæ, Sheets 1–92.
Volume II. Belgiæ Foederatæ, Sheets 1–132.

The plans of towns are coloured by hand, with their shields of arms illuminated. Believed to be *unique*; the copy in the Royal Library, British Museum is uncoloured, and the title of Volume II. reads "Novum ac Magnum Theatrum Urbium Belgicæ liberæ ac foederatæ." Therefore the copy in the R.A. Library is the first impression previous to the separation of the Dutch provinces from Spain.

The maps of all eight volumes are engravings, magnificently coloured by hand, and all have titles, more or less highly ornamental. Many also have shields, containing the coats-of-arms of the different countries, divisions, towns, &c., handsomely illuminated with gold and silver. The volumes are bound in red velvet. They have been very recently carefully cleaned and restored.

An entry in the Committee Proceedings of the R.A. Library, dated 5th March, 1810, is as follows :—"The handsome present of Blaeu's Atlas in eight volumes was laid before the Committee, and General Lloyd requested to return their thanks to Col. Garstin, in the names of the Members of the Institution."

Another book of great interest is a copy of "Eikon Basilikê."—"The Pourtraicture of His Sacred Majestie in his Solitudes and

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Sufferings,"—with the folding plate by Marshall, prefixed. This (the second) edition of Eikon Basilikê was printed in London in 1648, shortly before King Charles's death, but not issued until after. After the execution, "the Prayers used by His Majestie in the time of His Sufferings," delivered to Dr. Juxon, and the King's speech to Lady Elizabeth and the Duke of Gloucester, immediately before his death, were added to the book. Copies were bound in black morocco, black edges, with cross-shaped clasps. The Royal cyphers, "C. R." surmounted by a crown, and with a skull underneath were impressed in gold on both sides—emblematical of the martyr's death. It is supposed that these copies were distributed, *in memoriam*, among the King's friends. The copy in the R.A. Library, is one of the rare copies in the original binding as above described, one clasp is missing. A copy is in the British Museum at 8122 *a* in later inferior binding.

"Speculum Belli Sacri; or the Looking-Glasse of the Holy War, wherein is discovered: The Evill of War, The Good of Warr, The Guide of War, &c." Alexander Leighton, M.D., born 1568, the author of this book, also wrote "Appeal to Parliament, or Sion's Plea against Prelacie. Printed the year and moneth wherein Rochell was lost" (September, 1628). For writing this work the author was twice publicly whipped and pilloried in Cheapside, his ears cut off, his nose twice slit, his cheeks branded with a red hot iron with the letters S.S. (Sower of Sedition), and was eleven years imprisoned in the Fleet, 1630.

The First Book of the Art of Metals, in which is Declared the manner of their Generation and the Concomitants of them." This curious book was written in Spanish by Albaro Alonso Barba, M.A., in the year 1640, and translated by Edward Montagu, Earl of Sandwich, in 1669. The sale of Barba's book on metals was prohibited in Spain under the penalty of the Inquisition.

Another interesting book is one published at Nürnberg in 1762. It is a collection of 124 hand-coloured plates, representing the uniforms of the German Army at that time, together with a short history of the various regiments.

The "Introduction to Logic, dedicated to the Great God, to the Virgin Mary without Sin, and to the beatified Stanislas de Kostka, in company of the Angles," is a curious manuscript in Latin, written in the second half of the 17th Century, presumably by a Jesuit, and was probably used as a text book in Colleges. The following is an account translated from "Hoefer Biographie Générale" of the Stanislas de Kostka mentioned in the dedication:—

Stanislas Kostka (Saint) born in 1550, at the Castle of Rostkow, died on the 15th August, 1568, at Rome. The son of a Polish senator, he distinguished himself from his childhood by his piety. After completing his studies at the College of the Jesuits in Vienna, he expressed his intention of joining their order, but to surmount the obstacles which his father and brother placed in the way of his vocation, he repaired to Dillengen, where the Provincial, Father Canisius, in order to try him, ordered him to wait at table on the pensioners of the college, and to take charge of their rooms. Sent thence to Rome,

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he was admitted to Holy Orders on the 28th October, 1567. Before 10 months had passed, however, he died, after an illness of a few days, at the age of eighteen. Clement VIII. beatified him in 1604, and Clement XI. canonised him. His body is buried at Rome in the Church of Saint Audré. His Saint's day is the 13th November.

A scarce book is "The Prospective Glasse of Warre, Shewing you a glimps of Warres Mystery, in her admirable Stratagems, Policies, Wayes, &c.," published in London in 1628. It was written by Edward Cooke, and dedicated to "The Honorable Sir John Cooke, Knight, Principall Secretarie of State to his Majestie." It contains four quaint woodcuts of battle formations for the three Arms, and two of the battle formation of a Roman Legion.

The commencement of "A Letter to a Member of Parliament concerning the four Regiments commonly called Mariners," published in London in 1699, is rather amusing, it runs: "Sir,—In my last I undertook to shew that the Establishment of the four Marine Regiments is an useless Charge to the People, a Nusance to the Navy, and dangerous to the Kingdom's Liberties." With this letter are bound up "Lawes and Ordinances of Warre," for the years 1639, 1642, and 1652. Also "A short History of Standing Armies in England," 1698, and "Articles de Guerre de François III.," 1739.

"Theorike and Practike of modern Warres, discoursed in Dialogue-wise, by Robert Barret," London, 1598. According to Lowndes, George Chalmers says that Shakespeare evidently alludes to this work in his "All's Well that Ends Well," Act IV., scene 3.

A scarce and interesting Military work is Colonel Robert Monro's account of "His Expedition with the worthy Scots Regiment (called Mac-Keyes Regiment) levied in 1626, by Sir Donald Mac-Key, Lord Rhees. This Regiment, according to the title page served, first under the King of Denmark during his wars against the Emperor, afterwards under the King of Sweden during his lifetime, and then under the Director-General, the Rex-chancellor Oxensterne and his Generalls. It was reduced after the Battle of Nerling to one company in September, 1634, at Worms in the Pfaltz.

An unsigned manuscript note on the first page is as follows:—"This book is exceeding scarce, being printed at the sole expense of Lord Rhees, and most of the copies (which were but few) given to his friends," *vide* "Stricture on Military Discipline," Preface, p. 5, work p. 154, &c., where the great scarcity of this book is mentioned.

A German work on "Fortification," by Daniel Speckle, the architect of the city of Strasburg, published at Strasburg in 1608, contains some very fine engravings. It also has facing the title page an unsigned and undated manuscript note which runs,—"This is the most scarce and most valuable book of Fortification in any language. It always sells for an extraordinary price in Germany and is an uncommon curiosity in England. This copy formerly belonged to General Napier, who paid £2 12*s*. 6*d*. for it in Germany. Sold in Payne's catalogue in 1773, for 3 guineas. *See* "Horneck's remarks on Modern Fortification," Introd., pp. 6 and 7. *See* "Robin's Mathematical Tracts, published by Dr. Willson, preface, page 9, &c."

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"The Great Art of Artillery of Casimir Simienowicz," translated from the French by Shelvocke. Illustrated with 22 copper plates, London, 1729. On the title page is the following in General Borgardt's handwriting:—"A present from Colonel Armstrong, Surveyor Generall. July 4, 1729. Albert Borgardt."

A Folio Volume in black letter, gilt edges, bound in leather, with the coronet of Thomas, Earl of Pembroke on the side, contains the Acts of Parliament of 1604 (the first year of the reign of James I.), 1606, 1607, 1610 and 1624. Also those of 1625 (the first year of the reign of Charles I.) and of 1627.

Another Folio work contains four volumes bound in one. The first is "Acts of Parliament made in the first Parliament of Charles I.;" held in person, at Edinburgh in 1633. The second is, "Laws and Acts of the first Parliament of Charles II.," held by commission in Edinburgh, in 1661. The third is "The Laws and Acts passed in the second session of the first Parliament of Charles II.," held by commission in Edinburgh in 1662. The fourth is "Laws and Acts passed in the third session of the first Parliament of Charles II.," held by commission in Edinburgh in 1663. At the end of this volume is an "Act rescinding two Acts passed in the last session of Parliament, Edinburgh, 1663. This is in black letter. The latter two volumes of this book are not in the British Museum. (May, 1884).

"Trattato di Scientia d'Arme," by Camillo Aggrippa, dedicated by the author to Cosmo de Medici, Duke of Florence; and published in Rome in 1553, is, according to Brunet, (Manual du Libraire). "Fort recherchi, à cause des figures qui sont dans le style de l'école de Marc Antoine." The book is a Treatise on Fencing, and certainly contains numerous very curious engravings.

Notes on a Collection of Artillery Drawings in the R.A. Library, Woolwich.

By the late Lieut.-Colonel F. Millre, V.C., Royal Artillery.

The drawings in this volume, No. 1678, were, until 1867, tied up in a rude sort of portfolio, made with two loose pieces of millboard, and marked outside "Venetian Artillery;" a name little applicable to the general contents. There was no memorandum to show how they were obtained, nor is there any record of the draughtsman's name.

The authorship of these plates may, however, be attributed with strong probability to Albert Borgardt, first Colonel of the Royal Regiment of Artillery, of whose professional industry and skilful drawing there are many examples extant. A manuscript collection in the R.A. Library, No. 11956, contains several drawings, of various dates from 1693 to 1722, some of which are fronts of fortification, beautifully coloured and elaborately finished, signed "Albert Borgardt, 1715." The inscription under one of the mortars, plate 24, "Buda, 1686," is in handwriting of the same character as the above signatures, and may well have reference to the siege in that year recorded among Borgard's personal services. It adds considerably to the interest of

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these drawings to have cause to believe that they were done by such a distinguished hand.

The subjects include several mortars, a few cannon, a petard, a pontoon and its carriage, a forge cart, and a triangle gyn, drawn to various scales. Some of the mortars are accompanied by a shell and a carcass, and there is a very peculiar hollow projectile, with cylindrical sides and a pointed base, at p. 27. Most of the pieces are mounted, and there are some mortar-beds drawn separately. Most of the series are well executed and carefully finished, but some are not carried beyond a pencil outline.

All the ordnance are of brass. Many of the mortars are cast in one piece, with a plate which was bolted down to the bed. Such pieces had no trunnions. The guns at pages 31, 33, and 34 are very curious from the form of their cascables and the manner in which they are mounted; No. 33 has a coat-of-arms on the reinforce which seems intended for that of the Board of Ordnance. No. 17 is also curious, and Nos. 27 and 28 are of a very peculiar construction. At p. 29 there is a missile whose application is not at all obvious.

One of the mortars (p. 26) is called "Sr. Hen^{n} Sheers": this gentleman was doubtless the Henry Sheares, Esq., who appears as "Comptroller" in a Train of Artillery organized for service against the Duke of Monmouth in 1695.

The bores are in all cases terminated by chambers, whose forms are very various. The majority of them are constructed on a principle which has long been disused, although it was very commonly applied in the 18th century, and Professor Muller, who wrote on Artillery in 1757 and 1780, considered it the best for obtaining the greatest effect from the powder upon the projectile. This principle, as stated by Muller, is that "It is not the inward figure of the chamber but its "entrance which produces the effect; because the smaller it is the "nearer it reduces the effect into the direction of the shell." (1780: Introduction, p. xx.) On this theory, the chambers were made spherical or pear-shaped, with a mouth of less diameter than the interior.

Two English mortars (at pp. 1 and 25) have an enlargement at the fore part of the chamber for the reception of a wooden bottom or tampion, which was formerly inserted between the powder and the shell. Others, probably foreign, have what Muller calls a "cup" at the vent end; the object of this was that the powder might be ignited at the extreme end of the charge. He states that experiments of his own proved the advantage of this arrangement for mortars.

The mortar-beds are generally of wood, strengthened with iron, but one of them (p. 10) is of brass, and very nearly of the same form as the iron land service beds in present use.

The shells and carcases are cast much thicker at the bottom than at the fuze-hole. They have generally lugs for lifting them, but at p. 21 they are fitted with holes like the "Lewis holes," adopted for our own 13-inch shells about 1860.

The sheets on which the drawings are made are numbered from 1 to 33, but Nos. 16, 17, and 29 are missing. As some of the sheets contain only one, and others have two drawings, I have given a separate number to each leaf for convenience of reference.

F. M.
8th June, 1867.

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List of the Drawings.

(*The references are to the numbers in red ink on the leaves.*)

1. 13-inch mortar, with trunnions, on a wooden Sea Service bed; apparently an English piece.
3. 13-inch mortar, with base plate; an iron plug screwed in at the bottom of the chamber.
4. 12½-inch mortar, with base plate; marked "Genoa."
5. 13-inch mortar; fixed; also a "bomb" and a "carcasse."
6. 13-inch mortar, nearly similar to the last.
7. Plan of a Sea Service mortar-bed.
9. A short chambered piece, apparently ancient; 7-inch calibre.
10. 13-inch brass mortar, with trunnions, mounted on a brass bed similar to the present iron beds.
11. 11½-inch mortar, fixed and mounted; marked "Genoa."
12. 18-inch mortar, with a section of its bomb; marked "Tunis."
13. 12-inch mortar; marked "Tunnis."
14. 12-inch mortar; marked "Argiers."
15. 12½-inch mortar; marked "The last French Model."
16. 12½-inch mortar; marked "Genoa."
17. A short chambered brass piece, with three greyhounds (?) upon it.
19. A mortar with trunnions; no scale.
21. 18½-inch pierrier or mortar; the shell fitted with Lewis holes.
23. The same, in pencil.
24. 15-inch mortar, with trunnions; marked "Buda 1686."
25. 12½-inch mortar, with *trunnions*.
26. The same, mounted for Sea Service, and called "S^{r} Hen^{n} Sheers Mortar."
27. Piece of *special construction*, and with a peculiar kind of shell.
28. Another abnormal piece.
29. A chamber-bored cannon, accompanied by a peculiar missile or machine.
30. 10½-inch mortar.
31. Curious piece attached to an iron carriage by means of a flat cascable.
32. A long chamber-bored piece on a "rear-chock" carriage.
33. A piece nearly similar to No. 31, but on field carriage.
34. Another piece like No. 31; 9 inches calibre.
35. Section of a bomb-ketch; transverse.
37. Another section, probably longitudinal.
39. Drawings of a pontoon, showing the sides, ends and bottom.
40. Perspective general view of a pontoon, with balks, &c.
41. Wooden bed for a mortar; three views.
43. Forge cart, with anvil, &c.
44. Triangle gyn; probably of a foreign pattern.
45. 10-inch mortar-bed; similar to No. 41.
47. 15-inch mortar-bed.
49. Petard, with its appurtenances.
52. 18-inch mortar-bed.
54. 13-inch mortar bed.
56. "S^{r} Martin Beckman's Carriage to his 18-inch Mortar."
58. } Brass field gun, with the brackets, wheel, nave, and axletree of its carriage.
60. }

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Table of the Guns and Mortars in the Collection.

No.	Guns and Mortars.	Length.		Weight.	Remarks.
		Bore.	Piece.		
	Guns.	Cals.	ft. ins.	lbs.	
9	7-inch; short chambered...	5½	3 9	...	...
32	5-inch; chambered	13½	6 3	...	...
27	4-inch; do.	6½	4 0	...	With a curious shell.
28	6-inch; do.	11¾	7 0	...	...
34	9-inch, with flat cascable...	3	2 9	...	...
31	5-inch, do. ...	5	2 7	...	...
33	3-inch, do. ...	10⅓	2 6	...	With the Ordnance (?) Arms.
29	Chambered piece	8⅓	...	...	...
17	Do.	4	...	...	3 greyhounds on the exterior.
	Mortars.				
21	18½-inch (perrier)	2¼	4 0	...	Trunnions in the middle.
12	18-inch, "Tunis"	2⅛	4 3	8,699	...
24	15-inch, "Buda, 1686" ...	2⅓	3 9	...	...
5	13-inch	3½	4 8	...	...
1	Do.	3⅓	5 6	...	...
6	Do.	3⅓	4 5	...	...
10	Do., "Argiers"	2	3 2	...	...
3	Do.	3½	4 10	...	...
4	12½-inch, "Genoa"	2⅔	3 6	6,900	...
16	Do. "Genoa"	2⅔	3 6	6,900	...
15	Do. "French"	2⅛	3 2	7,000	...
26	Do. "Sir H. Sheers" ...	3	4 7	...	52½ cwt.
13	12-inch, "Tunis"	4	3 0	6,940	...
14	Do. "Argiers"	3⅔	2 9	...	...
11	11½-inch, "Genoa"	3	3 0	...	...
30	10½-inch	3	3 0	...	...

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DISCUSSION OF THE PRIZE ESSAYS,

(*Published in the R. A. I. Proceedings, in Nos. 12 and 13, Vol. XIV.*)

HELD AT THE

ROYAL ARTILLERY INSTITUTION, WOOLWICH,

ON MONDAY, 11TH OCTOBER, 1886.

Major-Gen. H. A. SMYTH (Commanding Woolwich District), in the Chair.

THIS discussion, the first of the kind held at the Institution, was convened at the suggestion of the Committee with a view to eliciting further information on the ARTILLERY DEFENCE OF A FIRST-CLASS FORTRESS, a subject of so wide a scope that to treat it exhaustively in the limited space of 16 pages, as allowed by the Rules, was considered by the Committee a virtual impossibility, whilst its importance imperatively demanded the fullest investigation from a national point of view. Officers of every branch of the Service had been invited to attend the Meeting in order that many shades of opinion might be represented and the subject thoroughly discussed.

THE CHAIRMAN.—Gentlemen; I think we can afford a moment to congratulate ourselves on the continued success of this Institution, of the Institution,—the Annual Essay. We have not got Colonel Duncan here, to whom I think we owe its origin; but it is a good thing for him to see, and we must congratulate ourselves on the having such a number of good Essays written on such a big subject. We must also congratulate ourselves upon having a Committee who found such a comprehensive subject, which really afforded space for so many Essays. My point is this: that we have three Prize Essays, that is, rewarded in various forms; and although you cannot say that any one Essay is perfect in itself, some are good in one point and some in another; and, in reality, the three of them together go towards making up the whole answer to the question which was put before the competitors.

I have a letter from Sir Michael Biddulph, who is very sorry not to be able to come here, and he says, speaking of the three Essays, "The points omitted here are treated of there. Altogether I think that the three Essays might be weaved into measures to be taken by the Government and into regulations for the conduct and duties of practice, and might form a basis of orders for an actual state of war." That is certainly a spirited statement of the case. For my own part I should

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prefer to cut and carve at the Essays somewhat before proceeding to base upon them any re-organised regulations. But I have given you also Sir Michael Biddulph's views.

General Brackenbury also regrets that he is prevented from being here to night; he fully meant to have come last Monday.

As it is, we will proceed with the discussion. We have not many rules on the subject; the rules which affect the discussion on Lectures do not apply here. We only say, I think, that everybody should keep as near the subject in hand as may be, and should not allow himself to be led off into the many important branch-roads that offer themselves. For the rest, I hope that any commentator will feel himself at liberty to speak out. We are all friends, and we want to elicit one another's views without mincing matters, and I hope that it will be done in a thorough give-and-take sort of manner, so that the discussion may be useful and frank and friendly.—(Hear, hear).

Major S. C. Pratt.—General Smyth, and gentlemen: I have been asked to start this discussion, and I will confine my remarks to two points. Firstly, a great portion of Major White's Essay is taken up with a description of Major Watkin's range-finder. Now, I think, that, generally, Artillery officers are somewhat suspicious of range-finders. It is credibly reported that nine officers of Artillery out of ten, at one period or other in their existence, have invented a range-finder which has been more or less successful,—generally less so. With regard to Major Watkin's range-finder, we have reason to believe that it is really a great step in advance beyond anything that has hitherto been invented; and if we contrast, briefly, our present system of obtaining effective gunnery with what it will be under Major Watkin's system, I think we shall see at once the enormous stride which his invention enables us to take. Take briefly an illustration. For instance, at Gibraltar, we have exceptional arrangements for taking the ranges of floating targets, telegraphing the information down to the batteries, and then the officer in charge fires at the target in the usual way. Yesterday I was talking to an officer who had been some time in Gibraltar, and I asked him casually if he had ever gone down to see the Artillery practice. He was not an Artillery officer. "Yes," he said, "he had been down, because he found it so 'exciting.'" That is not a usual epithet to apply to artillery practice, and I asked him the meaning of it. He said, "Well, the last time I was down I saw a steam-launch taking a target across the artillery range. There were three or four shots which went on different sides of the target tolerably close to it; but the last shot went quite under the stern of the steam-launch, so close that it seemed to cut the screw. The steam-launch made several eccentric movements for a short time, as if it had lost its head, and then suddenly made a very straight course down to the nearest landing stage at Gibraltar. Eventually, the officer in command of it was found in one of the nearest messes declaring, after imbibing several alcoholic drinks, that under no conditions would he drag a target again across the artillery range." Of course that was an exceptional case, but still it is an

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instance of what may happen under modern conditions when firing with heavy guns at floating targets in motion.

Take the other case. I had the good fortune to witness an experiment on Major Watkin's system at Plymouth under what we may call Service conditions. Everything was tolerably unfavourable; the weather was bad; the range was obstructed; they had only recruits who had been but a few days at drill to serve the guns; the guns were in casemates; Major Watkin had only a very short time to put up his range-finder. Two 10-inch guns were fired by the recruits at a target going about six knots an hour nearly two miles away, with a heavy sea in front of the range. The officer in the casemates had nothing to do except to look at a dial on the face of the wall, which gave him the training and elevation of the gun. Every now and then an electric signal came from a point above at which the observer was. "Are you ready?" The gun was made ready and the men stood clear without having any trouble about laying it. The observer from a distance, who had a clear range of vision, by putting his finger on an electric key sent off those two guns. You could see the shots in the air falling on the target at 3000 yards range a few feet apart on the water-line. Any one who knows Major Watkin's system knows that what can be done with those two guns can be done with any group of guns; and my first point is that the system of Major Watkin, or one similar to it, is a power to our coast batteries which we have never before possessed, and which we, as a Regiment, ought to try as far as possible to establish and to work for our own benefit.

The second point which I would refer to is the general question of Harbour Defence. I had the opportunity the other day of being present, as a spectator, when a certain portion of the Fleet attacked the harbour of Milford Haven. General Smyth, who was then the chief umpire, made the umpire rules, and no doubt has formed his official opinions on the subject. I only went as a spectator, and my views are simply given as such. If one were to try to describe the defence arrangements in one word, I, as an outsider, should put it briefly as "chaos." There were so many different people all doing their work well but, as it were, clashing together. At Milford Haven we had first, the Engineers, who laid down an elaborate system of mines, and protected those mines by a boom of wood. Then beyond there was a further system of electro-contact mines. That was one branch of the defence. Then a second portion of the defence consisted of the Engineers working from the land with electric searchlights on the mine-field and in front of the mine-field, so as to light up the enemy's boats as they advanced to the attack. Thirdly, we had the naval people, who had torpedo boats and guard boats, who worked on the system which they thought most applicable to the defence. Fourthly, we had several heavy batteries which, under the Umpire's Rules, were to fire on the boats as they saw them.

Now what was the result? All these people were more or less working against one another. When the attack came off, I was right in the middle of it. To and fro across the mine-field, just were the guns were supposed to fire, the defence boats were crossing equally

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with the attack boats. The electric light at the side was working quite irrespectively of the people who worked the guns. It is quite impossible by the electric light to distinguish between an attacking boat and a defence boat; and I think there was not the slightest doubt that during a considerable portion of the time the defenders were firing into their own boats.

There are a great many lessons to be learnt, no doubt, from the Milford Haven experiments; but the lesson that has reference to this discussion is simply this:—that we must have a unity of command in the matter of the sea defences of our dockyards and arsenals; and I do not think we can get that unless we have something which we have not at present; that is to say, what, for want of a better name, I should call "Fortress Companies," or "Fortress Batteries," composed of men who are thoroughly capable of looking after all the electrical arrangements connected with the guns, and also those connected with the mines. Whether it is possible for us to get the submarine mining arrangements out of the hands of the Engineers I do not know; but if it is not, I would put it forward, Sir, as a suggestion, that a certain portion of our Regiment, in combination with the Engineers, should be set apart for working the sea defences of these forts, and that those men so set apart, whether they were Engineers or whether they were Artillery, ought to be under one command and under similar conditions of pay and emolument.—(Cheers).

Captain Orde Browne, *late* R.A.—I understand that the object of this discussion is not at all to pay compliments or to refer to what we find that is good in these papers,—we may take that for granted because Major White's is a Gold Medal Paper,—but it is desirable to find out anything that we disagree with, so as to promote discussion as much as possible. Therefore I need occupy no time in saying how much appears to me to be admirable in the paper. With a view to discussion, I looked out for something that I could disagree with. Now on page 500 of Major White's Essay, I find something I thoroughly disagree with, namely, I think there is not sufficient recognition of the necessity of combination of the Artillery fire with the mines. I believe it was laid down, after the American War especially, in all the best books, that if a channel is defended by a complete combination of fire and mines, ships cannot force it, but that ships will always force a channel which is defended only by one of those means of defence and not by the two together. If it is defended only by mines, the ships will gradually fish them up by some means; if it is defended only by guns, ships will always force their way past the guns. I think that is not kept in view in page 500 of Major White's Essay, where he says,—"These matters cannot be left to chance. Take for example the case of an enemy's ship which approaches a channel well laid with mines—there it would be folly to oppose a serious artillery fire." I should have thought that it would be folly *not* to oppose a serious artillery fire. Then, further on, he says,—"Such information," referring to some sheets showing, by diagrams, the appearance and position of the important vessels of the enemy's

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navy, and giving other information, "would be of priceless value, for it would decide once for all whether fire should be opened at all; and if at all, when and where it should be directed for any effect." I do not know whether this is meant to apply to the same circumstances; it may or may not do so; but I will take the first quotation, namely, the suggestion, "that if the passage is well closed with mines you might waste fire on an approaching ship," and I will assume this to apply only to what he speaks of as the primary fire, that is, the fire of such very heavy guns as may be supposed to be capable of reaching the vital parts of a ship and destroying it. If you reserve your fire, one of three things would happen. Either the ship would go on and be destroyed by the mines—that would be the best thing that could happen—but even then the artillery would suffer from people observing that the artillery fire was not forthcoming; thus they would lose confidence in it, for the future underrate it, and probably say to themselves, "It is a good thing that we had the mines." That may be a comparatively small evil. I will next take the second contingency. Suppose that by some possibility, something goes wrong with the mines, and the ship gets safely through them, then you would indeed be sorry that you had not brought the guns to bear. Lastly, supposing that the ship finds that there is no fire directed on her, and suspects that she has been drawn into some trap, she might haul off and stand out to sea. But while I think in this particular case it would be a mistake to reserve your fire, I fully admit that it is most important that the saving of ammunition should be kept in view throughout, especially by the employment of what Major White calls secondary fire to support the very heavy guns, and prevent the waste of their ammunition on minor objects. Take such a fort as the Turret at Dover; that might be possibly attacked by small vessels. I have in my pocket a letter from Sir Nathaniel Burnaby written on the subject to me, in which he says that if ever English forts are attacked, it would be by small vessels in large numbers. If that was the case, a fort that stood isolated to any extent would be very badly placed if it had to expend its heavy ammunition unnecessarily. The expenditure of ammunition is a still more serious consideration with ships which carry a very limited number of rounds. Every case has its own peculiarities, but very often it is extremely unsafe for vessels to fire the limited number of rounds that they have. I believe that when the attack on the forts at Alexandria took place, the contingency had to be taken into account that the Fleet might possibly have to suddenly fight the fleet of another power. If ships have only 100 or 200 rounds per gun, of course the limit of ammunition each vessel can fire is very restricted.

Every powerful battery then, I think, should have guns near it of a secondary calibre to support it and save the ammunition as much as possible; and if the case is contemplated of a fleet really fighting a fort, and not merely running past it, but having to engage it for any length of time, surely it might be a good plan to mask the best guns and make play with all the secondary guns until you had drawn such ammunition as the ships can afford to give and, if they gain confidence,

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draw in close, then you can unmask the primary guns. I do not take it that a vessel can know exactly what sort of projectiles are being fired at her, and if she gets confidence from the small injury inflicted on her, she might gradually draw in. Perhaps Major White would tell us by and by what he thinks on the subject of the combination of the guns with the mines, and also of the support of heavy guns by secondary armaments, with a view to saving ammunition as much as possible.

COLONEL E. MARKHAM.—General Smyth, and gentlemen: a remark has just been made by Major Pratt with reference to some practice made at Gibraltar; I think the case he alludes to must have happened at the time I was in command there. I fancy that he must have been somewhat misinformed as to the circumstances. A meeting like this is hardly the place in which to give an explanation of a matter of that sort, but I think it is right to say that the practice was not from the 38-ton gun only; the practice was from the batteries of Gibraltar at a target representing an enemy's ship, towed by a steam launch, coming into the harbour, and being fired at in succession by each battery as it passed. There was, no doubt, great excitement at the time amongst the men, and they were very anxious to make good shots. A serjeant, I believe, laid the gun on the steam-launch, and when he gave the word "Ready," the man who had the lanyard in his hand, being in a very excited state, pulled the lanyard and let fly almost before the launch had passed the mark, and I am not sure that the shot did not cut the tow-rope close to the stern of the launch.[1] Major Pratt will, I think, excuse my mentioning this.

There are one or two other things that I should like to refer to, although I think there is really very little to say, because, as General Smyth says, the three Essays taken together have exhausted nearly the whole of the subject.

In these days naval tactics, as is remarked in one of these essays, have very much altered, and the attack of a fortress is not now what it was in old times. In the old days the Admiral ordered his fleet to attack in line ahead or in line abreast, as he pleased, and he came to close quarters and bombarded. I rather think we imagine that in these days an enemy's fleet is going to attack us in the same way; but it appears to me that that will not be quite the case. Naval tactics, as I say, have very much altered, and I think that the Artillery Commanders of fortresses ought to have some knowledge of the form of attack which will be directed against their particular form of fortress. (Hear, hear). This is only to be done by appealing to naval officers, and I think that some Naval Commanders ought to be instructed to examine each fortress. All our sea-forts are different, and a different form of attack would be necessary for each; but if a naval officer were directed to examine and advise as to two or three modes of attacking that fortress under the naval tactics of the present day, and submitted his ideas to the Admiralty, and the Admiralty communicated them to

[1] The fact was it was really a very good shot, although the Sergeant was of course wrong in laying on the launch.

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the War Office, and so on until they reached the officer commanding Royal Artillery in those fortresses, those officers would be far better prepared to establish a good defence than they are at present.

Major White remarked, also, as to certain people having an impression that it would be better to have armour-piercing guns in separate emplacements, and not placed together in batteries. It is my opinion (though I may be wrong) that that is quite the line that should be taken where available ground can be obtained for making those emplacements, and those guns should be on the Moncrieff disappearing system. But I dare say some difficulties would arise in grouping the guns together, because if they were placed at some distance apart, it would be more difficult for Major Watkin's Position-finder to direct the firing.

We may remark also that Major White has not said much about the *personnel*. The writer of the Silver Medal Essay, Major Rainsford-Hannay, has gone into that subject to a certain extent, and so also has Captain Nash; but neither of them has gone quite so far as I should have liked to see him go. There is no doubt that when war occurs, places like Gibraltar, Malta, and perhaps Bermuda, Halifax, and our Colonies where there are large forts, would denude our home garrisons of a very large force of Garrison Artillery. One of the essayists (I think, Captain Nash) says that of course they would be supplemented at home by the Auxiliary Forces,—the Militia and the Volunteers. But when war occurs, we are not prepared to work these forts with men who come into them at a day's notice. We have heard what Major Pratt has said as to the necessity of men being thoroughly acquainted with every part of the fort in which they have to work, because they are very complicated places, and their armament is very complicated, with all the hydraulic machinery, and, it may be, steam machinery, and all the new contrivances. In time of war the Royal Artillery are removed from these places and sent abroad; but it appears to me to be quite necessary that a few men should be left in each place to do the chief duties at the guns. Are we to expect that the Volunteers or the Militia will be able to step in immediately and take up the duties as if they were accustomed to them, never having seen these mechanical contrivances before, and perhaps only having been working a 40-pounder Armstrong gun, or possibly a 64-pounder, or even an old 32-pounder smooth bore? You cannot expect these men at a moment's notice to step into a fort and work the guns at once, without any knowledge of them whatever. Therefore I think that when the usual Militia training comes on, the Militia should go to certain particular forts that they know, and that they should go to them every year, and that they should know the working of those forts, and know the armament; and that the Volunteers in the same way, when they can afford time to go out, should take their training, if only even for a week or ten days, in those forts that they will have to man.

It is hardly our place here to discuss what the Militia and Volunteers are to do. I suppose there is some organized system at the War Office, or in the Intelligence Department, by which all this is settled.

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But we know quite well that it has not been settled that the Militia and Volunteers shall go to these particular places for their training. It is rather taken for granted in the Essays that the men know their business, but I do not see how they can do so, if we are to fall back upon the Militia and Volunteer Artillery, and they do not know the places which they will be called upon to serve in.

I make these remarks, because any remarks made on this subject are very often taken notice of.—(Cheers).

MAJOR G. MACKINLAY.—I would refer to one point which has hardly been raised in the Essays;—whether the advantage of the defence of a maritime fortress over the attack has been increased by the new arrangements which have come into force in the last few years. If, as I believe, modern improvements have increased the power of the defence, the question then arises,—What methods will probably be adopted by the attack, and what consequent arrangements should be made by the defence to meet them? Taking it for granted that forts are properly prepared and armed with modern guns and appliances, there can be no doubt that position-finding contrivances, giving accuracy of fire, afford a great advantage to the defence. The naval service, on the other hand, does not possess a corresponding advantage; for, although war ships are armed with accurate guns, they have not a good range and position-finder, and the want of it is much felt.

Submarine mining has given an enormous addition to the power of defence, obliging the attacking ships either to remain stationary or to keep at a certain distance, or to proceed very slowly.

Assuming, then, that the defensive power of forts is increased, what alterations in the tactics of an enemy's fleet are likely to be adopted? Would there not be an increased probability of night attacks, or of ships slipping past the forts at night, or of surprises? The electric search light has been introduced, and increased vigilance will certainly be demanded; frequent rehearsals will be very necessary when, as Major Pratt has already pointed out, attention will be drawn to the present evils of divided command, and to the great necessity of having the sailors, Engineers, and Artillerymen of the defence welded together under one responsible head: and as the fight will probably go on at night, every effort should be made to prevent that chaos which we have just heard exists under the present organization.

Another subject which is dwelt upon in one of the Essays is the employment of machine and quick-firing guns; they are now coming into the armaments of forts, and they have already been adopted on board ship. They would seem to be much required to repel night attacks, on account of the rapidity of their fire, and their suitability for the comparatively short ranges at which night firing, even when aided by the electric light, must be conducted.

The only other point to which I would refer is accuracy of fire and training of the men. The navy have a means of practical training in aiming and laying which though economical is efficient; this system might be adopted with advantage in the Royal Artillery,—I mean by the attachment of Morris tubes or rifle barrels to guns. By laying

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the gun and firing the tube you can see whether the object aimed at is hit, and this is a much nearer approach to reality than simply drilling the men at laying the guns. In this way gunners might be more effectively trained in laying than they are at present.

Major H. S. S. Watkin.—I can quite endorse what Major Pratt and Captain Orde Browne have said about submarine and artillery defence. It is laid down by authority in the "Manual of Submarine Mining," that mines alone, or artillery alone, will not efficiently defend a channel, but that both combined render the passage by a fleet almost impossible. But as far as I can gather there has been nothing laid down as to the respective duties of the R.A. and R.E. in the command of a fort. Take the case of a night attack, and that at present there is only one electric light (though the late experiments at Milford Haven showed that four or five will be required), who is to have the control of that light, the R.A. to direct their guns, or the R.E. for their mines? I presume the senior officer of whichever corps he may belong will take the entire control of the fort; but before the time for action arrives, this question ought, I think, to be settled by authority. I quite agree as to what has been said as to the submarine mines and garrison artillery being joined together for coast defence. At present the Artillery officer knows practically nothing about the submarine defences; possibly the Engineer is as little acquainted with that of the Artillery; but if both were amalgamated into a Coast Defence Corps, the efficiency of the defence would be greatly increased.

Then, again, we greatly suffer from the small amount of practice our men get at working and firing big guns. I have experienced great difficulty in carrying out experiments with Position-finding, from the little acquaintance the men have with their guns, and on account of the noise they make when fired. I have seen a sergeant turn pale with fright at a 10-inch gun.

General Smyth.—Shotted or blank?

Major Watkin.—With shot; a little more noise than blank, perhaps; but really it is not the men's fault; how can they get accustomed to firing with the small allowance of ammunition, and how are they to become familiar with the working of these guns, when the best part of their time is taken up with fatigues, company, and carbine drills, and also, in many fortresses, from the difficulty of transporting the men to where these big guns are mounted?

The French, I believe, tried years ago to give the necessary training and practice, without the attendant expense, by mounting a small gun inside a big one. The men had then the excitement of actual practice at a target, and really laying their guns, and thus avoided that abominable,—"trail right," "trail left," "ready," "fire," we so often hear from the drill instructor.

These are the points which have struck me most forcibly in carrying out experiments. It is difficult for men to learn their drill without constant practice, for which, apparently, time is not available, and to make efficient practice without the ammunition, which is not allowed.

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MAJOR N. WALFORD.—The only subject upon which I can give any information, I think, is with regard to the remarks which have been made about the bombardment of Alexandria. Major White mentions in a note in his essay, as an example of the power of resistance of masonry to artillery fire, the defence made by the Hospital Battery at Alexandria. But there was no masonry there except the revetments used for keeping up the parapet. There was a large masonry magazine in the centre, covered by 30 or 35 feet of sand, but the gun emplacements had nothing in front of them except a 4-foot wall of soft stone, and these revetments in front of the guns were knocked absolutely to pieces; both the guns were so choked with the *débris* of the revetments that they could not be traversed at all, and the left gun was thrown over on its side. The battery was put out of action and rendered incapable of giving any fire at all. I believe that as a matter of bravado it was fired the second day, but that must have been without the guns having been laid, because they could not be traversed or elevated. The resistance of masonry in the Alexandria forts was almost *nil*.

In another place Major White refers to the parapets as being only of light sand. That is, I believe, now recognized as the very best material for parapets, and certainly anybody who saw the effect of the shells at Alexandria would conclude that it was so. In the bombardment of Alexandria there was only one shell that got through a parapet; and considering that some of these parapets were only five feet thick, and some from six feet up to twelve, it is evident that sand must be a much better material for parapets than earth. After the shell had penetrated the sand a very short distance, the shifting sand deflected it, and the shell left the parapet before it had pierced it.

The next point that I wish to mention is this. Major White implies that the principal damage to the ships was done at the time they were anchored. Perhaps I may be excused if I mention very briefly the conditions of the engagement. The ships were at first formed in line ahead, and passed the forts in that formation at a distance of about 1500 yards. As a matter of fact, it was during that time (two hours) that nearly the whole of the injuries to the ships were inflicted. I said so publicly in my lecture, and I have never found anybody to contradict me. They then withdrew out of action to a distance of about 2500 yards, and there anchored and bombarded the forts; and I was told by a newspaper correspondent who was present on the occasion, that the moment the ships anchored and commenced their fire, the fire of the forts slackened. That, I think, is proof positive, if any proof can be positive, that in future naval action against forts, ships are are very little to be feared so long as they are on the move; and they will be best kept on the move, I think, by the use of howitzer batteries in position in-shore, out of the sight of the ships. The moment a ship anchors, and its range is discovered by the Position-finder, a salvo should be fired at her from a howitzer battery, so as to compel the ship to shift her position; and while she is shifting her position her fire will be of very little value.

The next point to which I wish to draw attention,—almost the only one which was omitted by previous speakers—is the electric light.

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I do not know that I am a very strong believer in attacks by night, either by land or by sea; but if we are to have attacks by night it is important that we should make use of the electric light. Has any one ever tried laying a gun by the electric light? I should think it must be very difficult indeed. It is exceedingly difficult to lay a gun by moonlight, and I suppose the electric light is very little better than the brightest moonlight.

General Smyth has said that the subject given for the Essays was a very large subject. Speaking as one of the judges—the only one present to night,—it appears to me simply enormous; so large that I confess I was rather delighted that Captain Nash had somewhat avoided it. It is true that he avoided it by mistake, because he speaks of a fortress when he means a fort; but what he has said as to the defence of a fort seemed to me to be most excellent, though it did not cover the whole ground.

The defence of a fortress is so large a subject that no human being could put it on paper in 16 pages. There is, first, submarine mining, and then the defence of the land side of the fortress. That alone is a subject upon which a man might perfectly well write a volume, supposing that he knew anything about it. It appeared to me that the subject given for the Essay was really too large. Speaking as an individual, I should have preferred that it should have been, "The practical working of the Artillery Defence of a Fort." That, I think, might have been very well compressed into 16 pages, as shown by Captain Nash in his essay. But the Artillery defence of a first-class coast fortress includes the defence of the sea front, the defence of the land front, of which we know very little; the use of submarine mines, of which we, as a regiment at large, know nothing; and the use of guard boats and torpedo boats, and torpedo practice, of which we not only know nothing but never shall know anything. The subject therefore appears to me to be so large that it could not be completely dealt with within the limits assigned.—(Cheers.)

Colonel Markham.—I do not wish to trespass on ground which has already been gone over by Captain Orde Browne, but he was alluding to the primary armament of a fortress and to the secondary armament. I think it is perhaps rather taken for granted that all fortresses or forts have a primary and a secondary armament. I am afraid that is not the case; I think I know one or two instances where it is not so. Captain Orde Browne mentioned that it was hardly likely that heavy guns would throw away their shot upon small craft, and possibly would be attacked by small craft. The large iron-clads of the present day probably would not risk running over submarine mines. The result would be that they would send in a flotilla of small boats, which would hammer away and do a great deal of damage to a turret.

The same thing as to primary and secondary armaments may be said with regard to Gibraltar. Therefore the secondary armament which is talked of, to all intents and purposes does not exist except in certain places. I rather maintain that the Turret at Dover is not supported by a secondary armament. It is a very long way out at sea,—I dare say 800 to 1000 yards—and if it were attacked by these

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small vessels, that would make the range so much the longer for the guns that had to support it; and I certainly think that measures ought to be taken to place a certain number of quick-firing guns in the immediate neighbourhood of the Turret.

The other question that I was going to allude to, was the the position of the Commanding Officer of Artillery on the occasion of the attack of a fortress. He has a very difficult and responsible position. I think it is laid down in Major Rainsford-Hannay's essay that he should take up a position, and that he should be in communication with the District Commanders. Those District Commanders, as I understand it, would have the charge of the observing stations, from which Major Watkin's Position-finder would come into play. But the officer commanding the Artillery will have to select a position sometime beforehand, because it would have to be placed in telegraphic communication with the observing station. There may be several observing stations, and telegraphic communications are not laid in a single day. There is a great deal to be done. When I commanded in Gibraltar we tried the thing, and we appointed two observing stations. We got the Engineers to lay telegraph lines to certain central points, to groups of batteries, and it involved a good deal of work. It is not done immediately, and I take it as very probable that the Engineers at all stations would not have the means at hand, because they would want several telegraph instruments to lay down the line. All that should be ready at hand, or the work cannot be carried out.—(Hear, hear).

MAJOR WATKIN.—I may, perhaps, be allowed to mention what has actually been done in the way of laying guns at night, to which Major Walford has referred. An experiment was tried a short time ago by the Royal Engineers with the Position-finder for submarine mining at Plymouth, and it was found that with a very ordinary electric light we could follow a gun-boat with ease up to 2000 yards. Now, it is just as easy to train a gun to a given number of degrees on the arc by night as by day; and therefore with the aid of the Position-finder there would be no difficulty in laying guns at night. You do not actually lay the sights of the gun on the ship illuminated by the electric light, but the cross-wires of the Position-finder being laid on the ship, the range and training are sent automatically to the guns.

GENERAL SMYTH.—May I ask you to explain that a little further; I understand that the Position-finder does not lay the gun on a given object, but on a given square.

MAJOR WATKIN.—The latest pattern is a great improvement in that respect on the old Position-finder; we no longer use squares, and signal to the guns very slightly in advance, but have resorted to what has been termed, "*predicted firing.*" We found that with recruits and men not expert with the training and elevating gear it was hopeless to follow a ship going at any speed; and that they required from half-a-minute to a minute to simply train and elevate. So now the Position-finder traces the course of the ship, and when the guns

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are ready to lay, predicts the position the ship will occupy half-a-minute or more in advance. The dials on the gun-floor automatically indicate the range and training to hit that predicted position. When the guns are laid an electric tube is inserted, and a signal goes up to the observing station that all is ready for firing. The N.-C.-O. in charge of the Position-finder, which is of course laid on the predicted position, looks through the telescope and watches for the appearance of the ship in the field of view, and when she arrives at the cross-wire, presses a button, and the guns are fired. Thus if we have a small body of men well acquainted with the peculiarities of a fort and the working of the Position-finder, the rest of the work could be efficiently done by the Militia or Volunteers. At recent practice at a moving target towed in a zigzag course across the water, we succeeded in hitting the target five times out of ten rounds, the range varying from 2000 to 4000 yards, the gun being entirely laid by the predicted firing method.

One great advantage of position-finding is that the fort can really be commanded and fought by one officer. Take, for instance, Bovisand, one of the outer defences of Plymouth Harbour, there we shall have six Position-finders, separated from one another, but connected by a covered way; the commanding officer has simply to go from one instrument to another and point out the ship he requires the guns worked by those instruments to fire at. Each group is bound to follow and be truly laid for the particular ship the telescope of the Position-finder is aimed at. I may mention, incidentally, one great improvement that I trust ere long will be carried out, that is the graduating of the index plate with ranges, instead of degrees.

It is obvious that for a gun mounted at any given height above the sea, each degree of *quadrant elevation* shown on the index plate, represents a certain range. Why then not at once have a scale of ranges, and not bother the men with degrees, which without a table (and I venture to say not one of our forts have one) is absolutely useless.

General Smyth.—Can you tell to what extent, if any, the Position-finder has been introduced into the Service?

Major Watkin.—I hope by April next the outer defences of Plymouth, the Needles, Hatherwood, Cliff End, and Hurst Castle will be thoroughly set up with Position-finders. It may interest officers to know that Hurst will be worked by a Position-finder at Needles, three miles distant; Breakwater Fort will be worked from Staddon Heights, a cable has already been laid, and conversation by means of telephones is found to be loud and clear, notwithstanding the other current passing. I wish I could have had a Position-finder here to night, to show the method of working, as a description is difficult to follow.

Captain Leach.—I should like to refer to one point which is mentioned by Major Rainsford-Hannay in his essay, and which has also been referred to by Major Watkin and Colonel Markham, and that is the *personnel* of a fortress. A good many of the officers here present

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have probably not served in a garrison brigade, and do not know the difficulties connected with it, in the way of getting the men for the purposes of drill and ordinary parade work. If I am exceeding the limits of this discussion, Sir, I hope you will draw me up, but I think the subject might be gone into with advantage on an occasion like the present.

The difficulty in getting good results is, as Major Watkin has stated, that the men absolutely do not know their drill. The reason of that I think is not very far to seek: it is the number of employed men that there are in every garrison battery. You will, perhaps, be tired of hearing Gibraltar mentioned, but that is where my experience is derived from. There, out of the whole strength of the battery, the morning state showed on an average from 6 to 15 men available for parade purposes. How can any drill with the guns be carried out at Gibraltar if those are the only men that the commanding officer has available? And those men that he has available are, as a rule, the worst characters (if I may use such a term) of the battery. Every man who has a badge or who has a good character is drawing extra pay for duty, which is almost permanent, in the Ordnance Department. Anybody who has been on the Rock will know Sergeant Brown. Sergeant Brown, who is a sergeant belonging to one of the batteries, is in charge of the signal station; and his duties at the signal station are such that he never appears on any parade at all. It is hardly fair to expect a battery to be in a state of efficiency for the purposes of drill when they can never get men like that for a parade of any sort or kind, except, I believe, the C. R. A.'s parade, and Sergeant Brown does come down from the top of the Rock then.

With all the heavier guns that are mounted on the Rock, the opportunities for practice with them are few. The 100-ton guns mounted there are, so far as the hydraulic machinery for loading them goes, entirely, I believe, in charge of Engineers. Why should not the guns be placed entirely in charge of the Artillery? [Colonel Markham here remarked that that had been done]. When I was at Gibraltar the 100-ton guns had been fired by, I believe, Major White, who went out specially for the purpose of firing them. Beyond that nobody on the Rock knew anything about them at all. They were beautiful things to look at, but nobody could tell how they were to be loaded, or what the drill for them was, or anything connected with them in any way. While I was there no drill at all was done with the 100-ton gun. With respect to the 38-ton guns that are on the Rock, one was fired once, and that was under, you may say, the orders of Sergeant Brown, at a Guarda Costa boat. It was proposed while I was there to carry out practice with the 38-ton guns of the Town District; but, owing to the illness of some of the *Scorpions* living close by, it had to be postponed, which illness, I believe, generally comes on when there is a report that practice will take place. The annual practice was done with the 10-inch guns with the battery; but the difficulties of getting all the men to practice with the battery were very great, and a large number of my battery never attended the annual practice, owing to the number of employments.

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When Colonel Markham was there, I believe, some combined practice was carried out from the different guns along the "line wall," but, if Colonel Markham will not mind my saying so, that practice was unpopular with the men, simply because it was a new thing,—nobody understood anything about it, and it was so new that it had not had time to interest any of them, and they looked upon it as something out of the ordinary way, which was rather a nuisance. But I am perfectly sure that if it could have been carried out a little further, this practice along the "line wall" would become very popular with the men as well as the officers, and would be carried out well.

There is another point that I should like to draw attention to, and that is the subject of Commanding Officers' parades. On days when the men are allowed to come away from their employments, they are usually taken up by Lieut.-Colonels' parades on the Rock. These parades, in nine cases out of ten, are used for the purpose of battalion drill. The subject of battalion drill, I think, is hardly of the same degree of importance to artillerymen as the subject of our gun drill (hear, hear); and the working of the heavy guns on the Rock I think should come before the efficiency of the batteries in marching past, in combination with infantry regiments, for the purposes of the Queen's birthday and other parades of that sort.—(Hear, hear).

It has been suggested by Colonel Markham that the Auxiliary Forces would not be competent to take the places of the Royal Artillery in these fortresses with the 10-inch and other heavy guns, if those forces were sent to the Rock and to similar places. But why is that? Is not the principal reason because the Auxiliary Forces have as their principal aim and object to learn to march past and to do battalion drill well on their inspection day, and not that they should excel in gun drill? I think those officers who have seen the Auxiliary Forces at work will have found that those forces spend the greater part of their time in doing battalion drill and company drill.

One other point that I should like to mention is the fitting of Martini-Henry rifles on to the big guns. In the battery where I was quartered, in the King's Bastion, at Gibraltar, every facility was afforded for that. One of the 10-inch guns was in the men's recreation room. There is no reason, except the slight expense, why the men should not, for their own amusement, have either the Morris tube or the Martini-Henry rifle fitted on to the big guns, and I am quite sure that if that was carried out there would be a great improvement in the practice generally with the guns.—(Cheers).

Colonel Markham.—Captain Leach has, I think, almost recommenced the siege of Gibraltar; I am not going, under the circumstances, to undertake the defence to night.

General Smyth.—I am sure we shall all be happy to hear you at greater length upon a future occasion.

Captain Jackson, R.E.—As an Engineer, and therefore almost a layman in the matter, I feel great diffidence in speaking on the subject under discussion; but I should like to follow what Major Watkin

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has said with regard to the laying of guns. He has very ably shown us the use of the Position-finder, and I should like to lay stress on the necessity of it. It is imperatively necessary to take the laying of these heavy guns out of the hands of men who are liable to funk, or at all events to excitability. We must consider that the guns are so important, that you should utilize every shot to its utmost capacity. You cannot afford to waste a single shot from a big gun.

Something has been said about primary and secondary defences. From what I have seen of a good many of our Colonial harbour defences, I cannot help thinking that we shall be exceedingly fortunate if we have even the primary defences alone to rely upon. Therefore the big guns in encountering ships must make every shot tell; and for two reasons; first, that batteries often have only a very short time in which to fire at passing ships; and, second, that big guns are as vulnerable, almost, to evil chance, as little ones. To illustrate the latter point take the 100-ton guns at Gibraltar. During the time that one of these guns takes in firing a couple of rounds at some first-class iron-clad worthy of its prowess, several thousand Nordenfeldt bullets might be discharged at it, and any one who is acquainted with the emplacements will know that an unlucky shot might find its way into the loading port, and by cutting a hydraulic pipe, put the gun out of action.

Conversely, a single well-placed shot from a gun of sufficient calibre, may disable an iron-clad. In proportion then to the value of individual shots from heavy guns, is the importance of furnishing every conceivable mechanical assistance to an observer, who should not only be provided with the very best means for laying his gun, but should also be an expert and capable of doing the fullest justice to the gun.—(Cheers).

General Smyth.—Have any of the officers present taken part, within the last few years, in any practice at moving targets? If so it would be useful if they would let us know what sort of success they had.

If no other officer wishes to address us, I will put the question to Major White, whether he can give us any additional light on any of the points which have been raised.

Major A. W. White.—I feel that I am about the last person who ought to speak to-night, because I have already had my say. I find however that I am the only representative of the writers of the Essays, neither Major Rainsford-Hannay nor Captain Nash being present, so I suppose I must answer for the triplet.

Fortunately for me there is hardly anything in the way of criticism to reply to, so I may, I hope, assume that we have fairly expressed the opinions of the majority of our brother officers. I say "we," because we three really put the same ideas into different words, allowance being made for omissions which the limit of 16 pages rendered unavoidable.

In the discussion to-night, two points have been specially noticed, to which I will briefly refer.

Captain Orde Browne, in his remarks on the mutual relation of the

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defence by guns and by submarine mines, has made it evident that I at any rate did not make my meaning as clear as I ought in the matter. What I wanted to say at p. 500 amounted to nothing more than this,—that if your enemy were bent upon hanging himself, you might as well give him rope. I did not intend to go into the question of the best tactical use of torpedoes and submarine mines, which is I think one of the future, as regards the Royal Artillery.

The other point that I must notice is Major Walford's correction of my facts in respect to the attack on the forts at Alexandria. I have no doubt I was wrong in attributing some importance to the masonry of the Hospital Battery. I have never been to Alexandria, and my chief authority was the American official account of the forts,[1] which I must have misunderstood in this particular. I do not, however, think that this much affects the general conclusions I came to.

As regards the question of ships *versus* forts, no doubt, if in attacking forts, a fleet can, by anchoring close in, direct a fire upon them such as they cannot reply to—it gains the advantage. But this may not always be possible; and granted equal conditions, it seems to me that the forts would be more or less nonplussed if the ships manœuvred while in action. Certainly, the fact of the *Monarch* not having been once struck at Alexandria, seems to favour my view.

With regard to other matters discussed this evening, especially the question of the *personnel*, I am afraid that it is too late at this hour (I see it is already half-past ten) to go into them.

I cordially sympathize with those who have pointed out our great difficulties in working under the present system. I did not deal with the subject directly in my essay, because I thought that if the vast importance of systematic preparation applied to coast fortress defence were once fully appreciated, certain changes must follow as a matter of course. History affords us many examples of evils overcome less by direct opposition than by the spread of correct ideas, and with this feeling, I left the matter alone. Everyone knows that the question of our organization must be taken up sooner or later. The fruit is ripe, it is but a matter of time, when it will fall to the ground.

I do not think there is anything more that I can say, all the rest having been dealt with by other speakers.—(Cheers).

General Smyth.—Gentlemen; it has been a very agreeable and easy part for me, so far, to listen to this discussion, which has tended little in any direction contrary to the spirit of the Essays, and from which it would appear that we are all agreed on the main points.

I experience, however, a little difficulty now, as to whether I ought not to have got up and spoken earlier as a dissentient in some particulars, and as to whether I ought to mention my divergence at this late stage of the discussion. I ought, nevertheless, at least to

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[1] Report of the British Naval and Military Operations in Egypt, 1882, by Commander Casper F. Goodrich, U. S. Navy; published by the Navy Department.

I much regret that I had not then seen Major Walford's complete and interesting paper on the Bombardment of Alexandria, in the Proceedings of the R. U. S. Institution.

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glance at the various comments and remarks which have been contributed this evening.

Major Pratt brought up two principal points. Referring to the Milford Haven experiments, he spoke of the universal destruction, friends and foes alike, which appeared to him at one period to set in over certain areas of the water; he deduced therefrom the necessity for some understanding being arrived at amongst the various branches of the defence; and that necessity has been generally alluded to both in the Essays and in the remarks upon them. It is most true—and nothing I believe has come out more strongly in all our recent experience—that you must have intimate mutual co-operation amongst the various branches of the defence. They are so intricate, so different and so important to one another.

As to this case of the guard boats of the defence being destroyed by the artillery fire of their own side, that was simply owing to the want of the mutual understanding which should have existed,—in fact to a want of completeness in the plan of the defence. I think I am disclosing no secrets in saying that the guard boats went in for most ambitious schemes, which no known system of defence warranted them in going in for. They went out trying for naval victories, I might say, on the ocean, and they came back without them; but before their return they had been destroyed by the enemy, and they were again destroyed during their return by their own people.

With regard, however, to the other point brought forward by Major Pratt, the triumph of the Position-finder, it is really on that, that the successful course of the Gold Medal Essay principally runs, I think. That Essay solves all difficulties by the virtues of the Position-finder. I hope it is, as Major Watkin tells us, about to come into the Service in a perfect form. But I recollect it, at several past stages of my career, always about to come into the Service in a perfect form. I was a member of the Range-finding Committee in the year 1879, and I went down to Plymouth to witness one of the triumphs of the Position-finder there. It worked very nicely, and with all the appliances that we had, and with perfect confidence in it—nobody had any mistrust—when we fired at a target 12 feet by 40 feet, moving at the rate of five or six knots an hour (which is not very fast), two series of eight or nine rounds each, from the best kind of 10-inch guns, on the best mountings, we achieved all that could be wished, except that we did not succeed in hitting the target once (laughter). Afterwards, during the same year, at Portsmouth, for the sake of some experiments connected with submarine mining, I carried out a little practice at a moving target, without any preparations or scientific appliances, on the usual practice range and with the usual practice guns on their usual mountings, which were remarkably ill adapted for following moving objects with: the range, indeed, was much less than that of the Plymouth experiment, but the target was more than proportionately smaller, being a ship's row-boat; it was towed at the rate of eight knots; and, using only service methods, we made three hits in 16 rounds. At the end of that practice there was nothing left to fire at except a shattered plank or two at the end of the tow line.

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Therefore I say that we want the Position-finder proved, and we want it approved, and in the Service, before we can found our calculations upon it. I have no doubt as to its future success. I have no doubt that it is very good of its kind now; but we have not seen it in the Service yet.—(Hear, hear).

Captain Orde Browne mentioned a very important point, and that was that so little allusion was made to the combination of submarine mines with the fire of the forts; and herein, however thoroughly the essayists have gone into the points which they have discussed, they have still left a very important branch of the subject untouched. Perhaps it is not generally known, certainly it is not generally known in the outer world, and possibly it is not known much beyond head-quarter offices, that submarine mines are reckoned to be absolutely essential factors in the defence of sea fortresses. I heard Sir Andrew Clarke go so far as to say the other day, on a Committee, that submarine mines afforded in themselves a complete system of defence; that they would be very glad of any co-operating artillery fire that might be at hand, but that, in the worst event, they could take care of themselves with their own guard boats. Of course there is a great deal to be said on the other side; so much so that one of our own essayists has considered the mines only to be obstructions for the purpose of detaining the ships under the fire of the forts. That is, perhaps, the opposite extreme. But there can be little doubt that the use in defence of an arrangement of submarine mines will keep back the strongest armoured ships that ever were built, because their armour will not save them in the slightest degree. Then the assailants must either keep out at a distance, where they can do very little, or, if they risk approach, they must get out all their boats, they must bring an auxiliary squadron of gun boats and smaller vessels of all kinds, to sweep for your mines, to creep for them, to try every way of getting hold of your obstructions, by night; (they entirely give up the idea of doing anything with them by day); and they must lay a line of counter-mines (as they are called in the naval attack) to destroy all the defensive mines that may be found in a certain road. They must do this with very light vessels, because those of much draught of water would infallibly be caught by the mines. When they do this with their small craft, then is the opportunity for the guns; and they need not be 100-ton guns,—they need not be even 40-pounder guns; most of the quick-firing guns which are now being introduced will readily spoil the fastest torpedo boats. You want all sorts of guns, well managed, and firing effectively in spite of darkness and mist and smoke; and I believe that for this night work the Position-finder will be very useful. But it is yet for Major Watkin to show us, in the Lecture which I hope he is going to give us, that the Position-finder gives you fine shooting. I myself have seen better shooting with the eye, the range being known, than with any arrangement of a position-finder (hear, hear). So far as I know, if you can tell the distance, seeing the object, and seeing the effect you produce will tend both physically and morally to the success of any defence (hear, hear). Although I find some drawbacks to Major Watkin's

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Position-finder, so far as I know it, I have nothing whatever to say in opposition to the remarks which he has made here. He emphasized the necessity of submarine mines, lights and guns working together; but there is very little about that in the Essays. He also emphasized the necessity of practice; if you have practice with guns, you must also have practice with the Position-finder, and with the lights, and with everything that you mean to use.

Major Walford spoke of the effect of howitzer batteries on ships at anchor,—a very important point. Iron-clads are attackable especially through their decks or under their bottoms: heavy howitzer fire is very effective for their decks, and submarine mines for their bottoms.

We are thankful to Captain Leach for reminding us of the difficulties which always exist in getting together the men of garrison batteries. We always hope to see better times, but all we can expect, as a rule, is that the best will be made of such means as may be available; and though we may not get all the men in a battery, or even half of them, still I do not quite see that the absence of one Sergeant Brown at the top of the Rock is a sufficient excuse for his battery not being found on parade; and I do not think it explains why they should not have made the best of what they had there.

Captain Jackson says that it is most important that we should not waste a single shot; but I am not at all convinced that the Position-finder is a sure way to avoid wasting a single shot. My impression of it is (Major Watkin will, I hope, correct me if I am wrong) that you fire the whole of the guns of the group on parallel lines: if the guns are a considerable distance apart, their shot will not all strike one gun-boat which is coming toward them (hear, hear). One or two of them may hit it, but the whole four cannot hit it. Is that so?

Major Watkin.—The Position-finder which you, Sir, had to deal with in 1879 and the Position-finder of 1885 are absolutely different instruments; they are based on different principles. Instead of two observers we have one observer; we have no squares: we have the whole thing in one man's hand, and the accuracy of it was proved, I think, in the last practice, where five shots out of eleven hit a target going at the rate of eight knots an hour in a zigzag course, the guns being manned by recruits, who, as Major Pratt said, hardly knew their gun drill, and who absolutely could not lay the pointer on a given mark without making mistakes. I do not think we can have better proof than that, which has actually been done. But I think, Sir, you are judging from the 1879 instrument, which was a horizontal one, this, which is a vertical base Position-finder, being totally different, and the arrangements for firing and the arrangements for grouping the guns being totally different.

General Smyth.—With regard to the absolute difference of the systems, I should like to ask two questions. What was the size of the target on this occasion?

Major Watkin.—The same as was fired at in 1879,—40 feet; but in a zigzag course 40 feet reduces itself to a very small mark.[1]

[1] See Appendix, p. 68.

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GENERAL SMYTH.—Do you use groups?

MAJOR WATKIN.—Yes; but the groups are so arranged now that instead of there being a whole battery with one Position-finder, there is one Position-finder either to one gun, as at Breakwater, or to two or three or four guns, according to the arrangement of the fort.

GENERAL SMYTH.—Nevertheless, do not all the guns of the group fire on parallel lines?

MAJOR WATKIN.—Yes, certainly.

GENERAL SMYTH.—Then if you have the same object, some of them *must* miss.

MAJOR WATKIN.—Yes, but the groups are so arranged that few of the guns are wide apart.

GENERAL SMYTH.—We shall look forward to your next lecture on the subject.

The discussion then ended.

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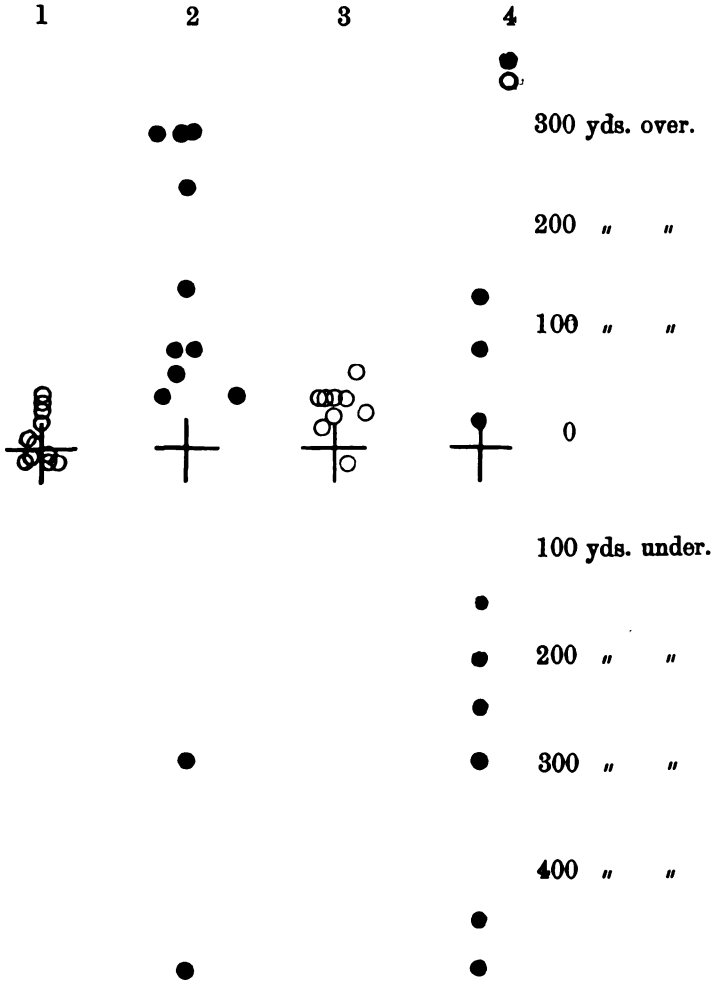
APPENDIX.

Results of practice in 1879, at Plymouth, with 10-inch R. M. L. gun; the target was towed in a zigzag course over the range, and the effects of each series of rounds recorded as below. Series 1 and 3 shew graze of shells using Position-finder, 2 and 4 those obtained using the gun sights in the ordinary manner:—



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COPY OF

REPORT OF VISIT TO MANDALAY

AND THE

IRRAWADDY FORTS, UPPER BURMA,

BY

COLONEL CAREY, R.A., COLONEL ON THE STAFF,

Commanding R.A., British Burma.

TO THE A.-Q.-M.-GENERAL, BRITISH BURMA DIVISION,

RANGOON, 16TH OCTOBER, 1885.

SIR—

I have the honor to report, for the information of the Major-General Commanding, that on the occasion of my late visit to Thayetmyo, to inspect the Royal Artillery there stationed, I took the opportunity to visit Mandalay, and with the kind assistance of Mr. Kennedy, Manager of the Irrawaddy Flotilla Company, and Captain Cooper, of the *Ashley Eden*, in which vessel I took passage, I was enabled to visit the following places:—

1. Khooleygone Fort, by land, *viâ* Patanago.
2. Myinhla redoubt.
3. Ava redoubt, or Segone Fort.
4. Ava.
5. Sagaing redoubt.
6. Thabyadan Fort.
7. Mandalay.

With regard to my trip, it was undertaken to verify the description given by Major MacNeill, Captain Yule, and others, and to satisfy myself as to the best mode of advancing on such positions, should it ever become necessary to do so. The accounts and drawings of the various places, as described in Major MacNeill's *Gazetteer of Burma*, dated 1883, are very correct, and any deviation from the account therein given has been ascertained by my personal inspection as I walked in, over, and round every fort in succession.

Whilst at Mandalay, I also gleaned the following information from the best source:—

In the Arsenal, which is in the fortified city of Mandalay, is a rifle

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breech-loading factory, where the Italians in the pay of the King of Burma are said to turn out Martini rifles of excellent quality. Besides this class of rifle, there is a large store of Enfield rifles and ammunition for them. Large quantities of ammunition for the Martini had, up to date, been smuggled in over the frontier. This ammunition was described to me as the Wetterli, Swiss patent, solid drawn cartridge, and had been imported in piano cases, billiard tables, sardine, maccaroni, and oil tins. The ammunition, however, is not a perfect fit, and machinery was in the course of erection to rectify the misfit. The number of breech-loading rifles in Burma is put down at 20,000. A mitrailleuse, pattern unknown, had lately been received, had been tried, and fired with success. Whether there is more than one is not known; and the ammunition for that one is in limited quantity. Two breech-loading guns, description unknown, had also been received, but it was said there was no ammunition for them.

With regard to smooth-bores, 12, 16, and 32-prs., brass guns form the principal stock, besides which are some iron (cast) guns, nature unknown. Particulars about the ammunition I was unable to ascertain; but the large figure of Guatama, formerly at Ava (I ought to have said at Amarapoora), and lately removed to Mandalay, weighing 40 tons, is said to have been brought up, *shot* being used as rollers to convey it.

It was also stated that guns had lately been sent to Nyingyan *viâ* Myingyan, and also to Myinhla redoubt or Khooleygone fort. The fact is confirmed by officers of the Irrawaddy Flotilla Company, who, it is said, saw them being landed.

Troops were to be sent to Nyingyan, on the Tounghoo route, under the Atwin Woon; while another force was to leave for Myinhla, where the Kyoung Myoung was to command.

Europeans, Italians I believe, had lately arrived in Mandalay for the express purpose of starting a gun foundry. The number of French in Mandalay are said to be 25, and Italians 15.

The war steamer *Bandola* is armed with six guns; they had been taken out of her and sent up to the Arsenal in the palace square to be overhauled.

With regard to the political state of affairs, it appears that the French are doing all they can to establish a *Société d'Exploitation* for Upper Burma; the gentlemen concerned being,—

Mons. Haas, French Consul, Mandalay.
" Voston, French Consul, Rangoon.
" Bonvilain, of Mandalay.
" Isambert, of Paris.
" Garongée, of Mandalay.
" Castille, of Paris.

The Burmese Ambassador, now in Paris, Mons. de Travaillac, was originally mixed up in the scheme, but, doubting the support of the French government, is said to have withdrawn his name.

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The object of the *Société* is to advance money to the Burmese government for securities in land, forests, mines, &c., more especially to obtain the concession of the forests, now worked by the British Burma Trading Company, Limited, the French government advancing the necessary funds to the *Société* for the purpose, and probably intending to claim the whole as French national property.

On Saturday, the 26th of September, a telegram was said to have been received in the Mandalay palace, stating that Mons. Garongée, then supposed to be in Europe, would be in Mandalay with from 18 to 24 lakhs of rupees within ten days. Mons. Garongée returned within the time named, having passed Thayetmyo on his way up on the first or second of October.

With regard to the scheme, the same was afterwards confirmed to me through a good French source. There is no doubt that all my movements from the time of leaving Thayetmyo as Mr. Carey, to my arrival in Mandalay as Colonel Carey, were closely watched and wired to the Burmese Court: and even after my departure, the Captain of the *Ashley Eden* was questioned by Burmese officials as to the object of my visit.

On arrival at Mandalay, in consideration of my rank, two officials, the Superintendent of Police, by name Hoo-Poo-Soo, and an interpreter, by name Nur-din, were placed at my disposal to escort me wherever I liked. They gave me every assistance that I required, and appeared rather anxious that I should visit Bhamo. This, however, under the present state of affairs, I deemed unadvisable, and pleaded want of time as an excuse, not knowing what 24 hours might produce. I also found a good deal of excitement in Mandalay among the Europeans, and more especially all British subjects, as to what was likely to occur. They talked of sending wives and children down the following week; and some have already come down. The general idea was, that Burma was as likely to force on a state of war with the British as not.

The Flotilla Company's steamers had their steamer fires relaid ready for lighting immediately after arrival, and no repairs were attempted on the engines that might interfere with the getting up of steam at the shortest notice. Although the feelings of the Court were excessively hostile and affairs threatening to foreigners, it is rumoured that, if the English would only show themselves in sufficient force and strong enough to take over the government of the country, a very large party would immediately join them: but the force must be strong enough to put down the present government completely.

Seeing this state of affairs (in fact getting a strong hint from a Mahomedan government official), I deemed it advisable to return by the first steamer after a three days' visit, instead of remaining a week to study Mandalay as I originally intended, as the knowledge I was likely to pick up after that date would not compensate for any forced detention, should disturbance arise.

The village of Patanago lies about five miles south of the Khoolegone fort, round the bend of the river, and is completely hidden from the fort. When the Irrawaddy is in flood, as at this time of the year (September)

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the water is close up to the top of the bank, from which a country cart track leads to Patanago, only twenty-five yards distant. The village runs parallel with the bank; houses on either side of a cart-road running right and left. That leading to the right continues for a few hundred yards and appears to bend round in a northerly direction and to follow a line nearly parallel to the ridge of hill running up the river-bank; probably it keeps about a mile distant from the ridge, and somewhat to the north of the fort strikes another road running due west to the fort by a village to the north of it and at no great distance. If any information can be obtained about this road, in the event of a large force defending the ridge, it might play an important part in a turning movement. That leading to the left continues for 200 or 300 yards along the river bank, when it bends inwards and rises on hard gravelly soil. This is the commencement of the hill-ridge extending to and beyond Khooleygone Fort: it is firm hard ground the whole way, and rises to its full height, about 450 feet, about half-way. The crest of the ridge does not extend inland more than from three quarters of a mile to one mile distant from the river or from Khooley-gone fort, at the point where the road turns west to the fort.

The whole of the ground on the river side is impassable for troops, owing to numerous and steep spurs. Neither is there any practicable landing between Patanago and the point north-west of the river above the fort, where a landing could be effected to gain the ridge directly. The landing at Patanago is not difficult, and guns and stores could be slung on to the bank with great facility. Moving up, the cart-road has a gravel soil, with a gradual rise to the top of the ridge. It took me an hour and a half to examine the country as far as Pongyee Kyoung, and the foot-paths leading to it from the river. Allowing half-an-hour for going out of the way, the distance would be an hour's walk, or about four miles. From thence it took me one hour exactly to gain the Infantry enclosure overlooking Khooleygone Fort. The road is invisible from the fort the whole way, and this is the only practicable land route to the fort. The country on either side is covered with jungle more or less thick, here and there being somewhat more open with a cultivated field. At one point of the road, a white pagoda on the fort spur, distant about half-a-mile, is visible. Here the road sweeps eastward to follow the crest of the ridge, and makes a wide sweep round to the west, when it leads direct on the fort one mile distant. A branch road at the turn runs north. The bend is rather north of the fort. It passes a water tank, which dries later, and is close by the pagoda already mentioned. From the point where the white pagoda comes in view the ground is tolerably open, but from the direction of the spurs, does not appear to be practicable for troops. However, two guns and a Company of Infantry placed at the bifurcation of the roads would take any force by the pagoda obliquely, support the advance of the column along the road, and cover its retreat in case of accident.

The Infantry enclosure is at present light bamboo lacing of six-inch squares of the weakest description. Unless the ridge is occupied strongly, a column will have no difficulty in moving up and forming

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for attack westward by the tank, where the ground opens out 300 or 400 yards, but narrows on the Infantry enclosure. This enclosure bars the road, which passes through its centre, the ricketty apology for a gate being further protected by an 18-inch square parapet about six feet long, with a ditch in rear, where five men might be posted. The ground is more open to the left, being the shoulder of another spur. I moved by the right, by a track just broad enough for single file, alongside the enclosure and the edge of steep ravines. On gaining the other side of the enclosure, one finds one's self on a hog's back, 200 yards distant from the fort. Here I left my men to sit and wait my return. I moved up under the other side of the barrack, crossed the head of the ravine on to the spur already spoken of, and followed it down on to its tongue opposite the fort.

A spur beyond this one, springing west out of the same cart road, presents a very abrupt appearance, one part showing a drop of nearly a hundred feet from the spot where the white pagoda first became visible. This ravine extends towards the road. Continuing my walk to the end of the spur, a full view of the south face of the fort was obtained—an earthen parapet without embrasures, with a level glacis in front through which a broad sallyport with masonry sides, allows of guns being run out and placed in position on the edge of the cliff. The battery, however, can be enfiladed from the ground, left rear of the Infantry enclosure. Descending the point of the spur and working back, I crossed by a dam (to retain water), moved along under the south to the east face, and regained the hog's back. Here finding that the masonry wall was not three feet high, I walked on to the parapet near a sentry-box, and up the parapet of the cavalier, and surveyed the interior, which has been well sketched in by Captain Yule. The fort resolves itself into a rectangle of masonry, the enclosing wall being so high that musketry fire is not available at present for defence. The gun battery has been described. In rear of the Infantry rectangle are the gun and store sheds. These are all on a lower level, defiladed from an attack south. Gaining the east face, there is one obstacle to be passed in the advance to storm the fort. About 30 yards in front of the east face an attacking column will find itself on the edge of a broad cutting across the hog's back, 20 ft. wide and about 10 feet deep in the centre; the slope of the hill allows advancing troops to turn this cutting. This column comes on the barracks, guard, and main gate entrance north. The rear of the column can wheel up through the buildings to the east face, and join in the storming, while the head forces the gate, and the centre covers the advance by pouring in volleys from the edge of the cutting on the east face.

The road passes round the north face barely passable for a cart, and falls off in steep ravines to the right. Beyond the fort the ground is open, but the spur is hardly broader than the fort, and narrows very quickly; it is precipitous to the south and steep to the north. No force landing at the point of the spur should be able to succeed in taking the fort, surrounded as it is with an eight-foot loop-holed masonry wall, bringing a converging fire on to the path by the White Pagoda about half-way down to the river, where there is

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hardly room for three men abreast. The fort covers the width of the spur in the widest part. Attacking from the land, *viâ* Patanago, leaving two guns and a Company of Infantry on the spot where the White Pagoda first becomes visible, to cover the advance, the column would march on and, after wheeling to the left, form for attack. The mountain guns (four) coming up on the left as ground becomes available, a couple of volleys would clear the enclosure, and the guns on the left would enfilade the gun battery. A force would have to be placed at the wheeling point to protect the right rear from attack from the north. The attack would reform; the centre on arrival at the cutting, halting, and pouring in volleys, while the wings overlapped and stormed the fort at the angles.

The whole, without further inland defences being met with on the Patanago road, should be carried out in three hours from marching off the advanced guard. The road will in all probability be defended, and a very large force be collected for its defence. The fort, however, must be taken and occupied, as otherwise river communication will always be harassed. This country is too thickly wooded for heavy artillery, nor could it be put in position to be in time for use.

When the column is advancing, the attention of the fort should be diverted from the river with an artillery attack. There are several spurs jutting out to the river from the ridge, which will come into possession of the land column as it gradually advances, from which communication by signal can be kept up with the fleet.

The Minhla redoubt lies on the opposite bank to Khooleygone fort. It appears to be built for the defence of the river up stream, and is on the north side of a point somewhat higher, the fort being at the foot of the slope and almost invisible until the point is turned. Nothing is to be feared from it, if let alone; but the ground south may be occupied down to Malloon. It then becomes a question as to which bank of the river should be occupied first. I would suggest that Khooleygone should be first attacked. Malloon will be unable to prevent landing at Patanago, and a little artillery practice would probably stop any desultory fire on the force.

However, not contemplating another defence of Malloon, it is possible that the Minhla fort may, or may not, be occupied. In the latter case, I should recommend its being garrisoned with a Company of Infantry, to overawe the neighbouring population, and ensure the safety of the landing place as a convenient place of call.

The fort is covered to the south and south-east by the river bank, which is nearly 40 ft. high. Running past the point, the north side is visible—a portion of its north-west face has fallen out, exposing its construction. A square of 65 yards, 20 feet in height, the outer faces are of brick about four feet thick, round an inner fort, whose walls are about 4½ feet distant and are four feet thick of masonry, the interval being filled in with earth, gives twelve feet thickness of parapet, 4 feet masonry, 4½ feet earth, 4 feet masonry. This construction is no doubt the cause of the fall of the broken down wall. The earth absorbed the rains and swelled, and that corner being rather lower than the rest, the drainage set that way, and the wall was thrust

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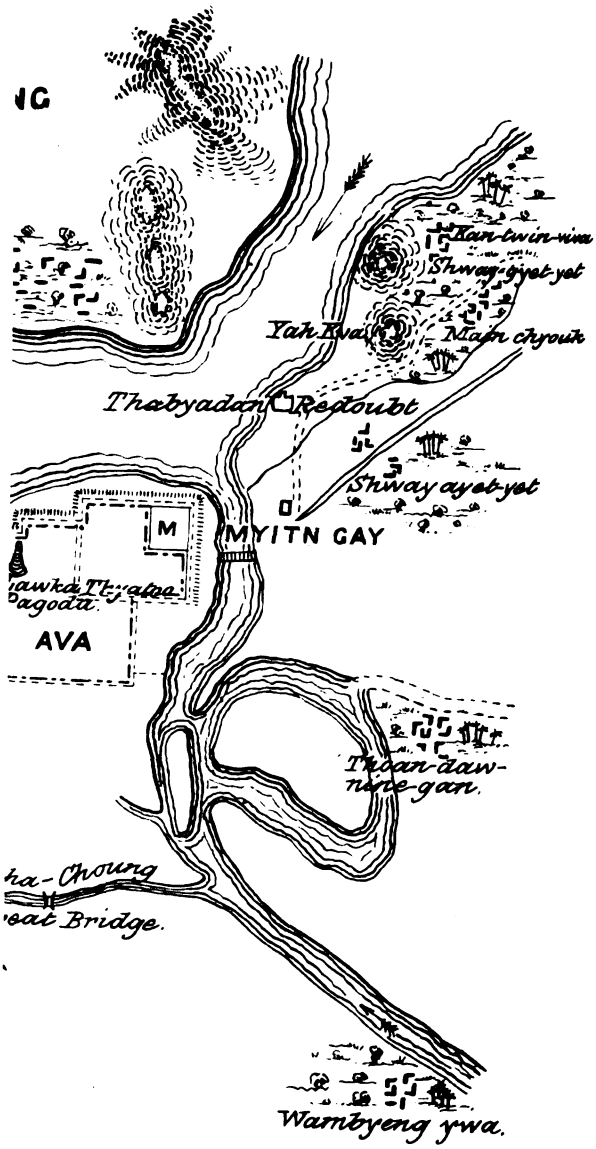

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out. Inside the fort are four casemates on each side for habitation and stores. They are of brick masonry, roofed over, and giving a terreplein on the top of the fort, about 20 feet broad, strong enough for Artillery. The interior slope is revetted with masonry, and of a convenient height for musketry fire. The entrance to the top is from the outside. On the west face is a projection about 15 feet square, from which two ramps lead to the ground, north and south. Under this ramp is the west entry gate into the fort basement. There is also an east gate entry through the village on the river bank. A hundred rifles located here would command the landing north and south, as well as keep the country quiet. The fort can be attacked with Artillery from the river. A few rounds from a 25-pr. R.M.L. gun would soon pierce the north face, while the village and east face could be assaulted from the landing; and more troops landed to the right and north of the attack, which moving south would take the west face in flank and cut off all attempt to escape. In this case an attempt should be made to storm the fort by the north ramp, and it ought not to fail.

If the fort is covered by an army, a battle would probably have to be fought south of the fort, about one mile distant, but with the fall of Khooleygone, no resistance or fight will be shown on the opposite bank.

Leaving Minhla, there are at present no military works to obstruct the passage of the river until arrival off the Segone Fort or Ava Redoubt.

The latter is a square redoubt with a ditch, at the extremity of the indented line of the Ava defence. The line runs on to the ditch of the fort, and so prevents its being turned up river. These lines can hardly be stormed, for, like the fort, between them and the river is a broad, though now dry and deep ditch. Some distance up the river the earth between the river and ditch has been washed away. The fort itself is 250 feet square, ditch 28 feet wide and 18 feet deep, with scarp and counterscarp of masonry all round; a bridge in rear, east face, crosses the ditch, the angles of the counterscarp of the ditch are cut off, so the ditch at the angle is not broader than the general width, 28 feet. Three-inch planks, 30 feet long, thrown across, would enable a force to storm the work. In front of the fort, west, looking down the river there is about one mile of level ground. At this distance, by native map, a creek called Myit-tha-Choung runs into the river; it comes round from the south of Ava. Here is a wood and a village, but about 800 yards up the river, half way between the creek and the fort on the bank, is a tope of palms. The ground is open to the front, while a small village and copse 400 yards nearer the fort protect it from rifle fire in that direction. It is, therefore, a suitable spot for landing a Brigade; the ground is fit, even at this date, the 25th September. Moving half left, a few hundred yards brings one on a cart track running to the south-west angle of the fort. Passing the copse on the left, in the line of advance, is a small swamp extending south, not very deep, and which will dry by degrees, the cart track crosses at a spot 20 yards wide, and only ankle deep. Cultivated ground lies on the right front, which is now irrigated, and extends south of the fort, coming down to within 50 yards of the south face. The berm of

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the fort and the top of the counterscarp, from which the glacis is gradually sloped off, are a few feet higher than the neighbourhood. Moving along the south face of the fort, the east and rear face is not only gained, but the whole of the Ava river line of defence is taken in reverse. Meanwhile another column having landed at palm tree tope, advancing half left, forms for attack across the front of the present site of the marsh, and advances. When within 200 to 300 yards of the fort, the Artillery fire from the river ceases, and the south face is carried with a rush. The left of the attack, if provided with half a dozen three-inch planks should throw them across the ditch and storm the work.

In the event of Sagaing fort proving too troublesome for the river attack on the north, Artillery can be landed at the palm tope, or still closer to the copse, from whence the fort can be shelled direct, and the south face enfiladed. The advantage of this mode of attack would be that the Artillery fire, covering the attack, could be kept up somewhat longer, but the advance would have to be delayed until the guns were landed. The first plan is therefore recommended. The interior of the fort is not casemated. A single flight of steps leads up the slope of the terreplein, which is wide enough for Artillery; but the parapet is somewhat too high in its present state for musketry fire, (about five feet.) Magazines are built in under the ramp. The passage was damp, and the magazine was said to contain powder. It was too dark to go in any distance.

Ava, the former capital of Burma, now abandoned, is mostly jungle, with a few small villages in it, the rest growing into waste jungle. Its length down the river is about 2½ miles; its width varies from ½ to 1½ miles. It is surrounded by an earthern embankment, originally about 20 feet high, in fair order by Segone redoubt, but broken through in several places on the river side higher up. The west face is a shapeless ridge, about seven feet high, easily crossed after passing round the ditch in its front.

It is quite possible an army might be located here under cover of the earthen parapets, in which case, steamers and flats would be annoyed by musketry fire from the river defence. If Ava is occupied in force, it would, for the foregoing reason, be necessary to attack and defeat the enemy.

Fort Segone having been taken, and the river embankment taken in reverse, the enemy closely followed up would be unable to show a front. The land force should, however, in this case, be strongly supported, and be prepared for a struggle at two points.

First, at about twenty minute's walk from the fort is the large pagoda. This stands in a quadrangle with four gates, one on each side, a gallery of six yards width runs round the interior, it is roofed, although somewhat out of repair, and without steps or stairs leading up to it, it could easily be mounted and made use of as a parapet. An army taken in flank and driven back, would naturally hold to such a place of refuge, and it would be necessary to dislodge them. Besides, further on, in the north-east corner, is the old palace, another twenty minutes distant. It is a strong masonry building, now used as a school, which after

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capture it might be necessary to occupy. The occupation by our troops of these two points, Segone fort, and the palace at the further end of the river, would effectually prevent the re-occupation of Ava before the expedition is withdrawn. With the possession of Ava lines, the expedition has virtual command of the Irrawaddy. However, Sagaing redoubt and the fort of Thabyadan have to be reduced. The former, Sagaing, is a mere redoubt, which can be shelled from the river; and a landing party in boats can storm it at the western corner, at the junction of the parapet and masonry wall. The fort is seven sided. The earthen parapet round six sides is run out beyond the edge of the river bank, so that half of the exterior slope is revetted with masonry, to prevent its being washed away with the rise of the river floods. The height of the parapet crest above the bank is about ten feet, the interior slope is of brick 4½ to 5 feet high. The terreplein is 20 feet wide, on which Artillery can be worked. The gorge is given at 250 feet, its depth from front to rear is about the same as the rest of the parapet, closed in rear by a fifteen or eighteen-inch masonry wall giving flank defence. This wall begins on either side at the river bank, where the earth ends, and is carried back into the jungle about 30 yards. In the east wall, in which is a wooden gate about 15 feet wide, there are 29 loopholes. In the western wall, in which is a two-foot wooden door or wicket, there are probably 35 loopholes. The rear wall, irregular, bastion-shaped, is also loopholed, and has a large wooden gate in the centre, similar to the one in the east face. On the east face is a stone slip up to the gate, but from the gate a cart track also runs to the river bank, describing an arc, with a chord of about 40 yards. This cart track also goes to the centre gate in rear of the fort, whence it leads to another cart track twenty yards in rear, running about east and west from down the river to the village of Sagaing. Following this track west one comes to the village of Dawayel, about twenty-five minutes distant. Here is a marble alabaster figure representing Chasindoo in a reclining position. Twenty minutes further on, in a somewhat more northerly direction, is the walled village of Choundogyee, opposite to which are some tolerably fine pagodas. At this date the remains of a crucified man were to be seen. The road eventually opens out in paddy fields, a good tank and zayal, being a quarter of an hour's distance from Choundogyee. The large round ruined pagoda of Moodawgyee, visible from the Irrawaddy, also comes in sight, showing that the jungle has terminated in that direction. The whole country traversed up to this point is thick garden jungle. Working round towards the river and eventually regaining Choundogyee, a branch road leading to the river was struck on the near side, distance one quarter of an hour. On clearing the jungle, at a point by a wooden pagoda, and an old brick pagoda, grassland extends about 800 yards up the river, and 200 yards in width to the river bank. Opposite on the edge of the bank is a solitary scrub bush or stunted tree. In line with the tree and pagoda is the Ava pagoda on the opposite bank. This line is just above Longgrass Island off Segone Fort. Here then, if it is desired to land a force to take Sagaing redoubt in rear, is a

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convenient spot. It is out of sight of the fort, which is round a point half a mile distant, the last few hundred yards being dense jungle to the river bank, and the landing can be effected under cover of guns from boats and vessels. A column can form up here, and by the road traced out, appear before the rear of the fort, if unopposed, in one hour's time. A second column proceeding up the grassland to the jungle, can turn into the left, and twenty yards on will strike a similar cart road leading to the wooden door, west face, at the junction of the loop-holed wall and earthen parapet, where the easiest place for storming the fort presents itself. On either side of the roadway are houses; no doubt the garrison of the fort live there. Mountain Artillery, even Field Artillery, can move by these roads. At this date they were quite dry enough for wheeled traffic. A large force might be collected in the jungle to oppose a landing, but under cover of Artillery fire from boat and mountain guns, and pushing up to the northern end of the grassland, there should be no great difficulty in clearing the wood between the landing and the village of Choundogyee and the redoubt. The redoubt should then be destroyed, the earthen parapet thrown over the river bank and the masonry walls destroyed and levelled, after which the enemy in this direction might be left alone.

We now come to the fort of Thabyadan on the opposite bank. One mile north of Ava, in the re-entering bend of the river, is the fort. It appears to be in a plain, its front and river flank covered by long grass. Landing under cover of this long grass, in five minutes a somewhat broad dark ditch is gained. It is not only full of water, but also of deep black mud, representing the mud of a *choung*. There was no getting over this; so moving half left for the river, passing small inlets of the same nature, with bamboo fences across them, quite enough to delay an enemy and keep him under fire of the fort, I regained the boat. Moving up the river, a landing will be found at the north-west angle in rear, it is firm and hard, passes through long grass, and places one on the rear angle of the masonry berm four feet wide and not two feet high at this point. This fort is five sided, with a masonry berm, earthen parapet, easily stormed. Along the berm, the face measures 65 yards. The ditch has evidently been made by excavating for the glacis up to the berm or close to it, it is of irregular shape, but stopping short of the landing place extends round the fort and along the rear face until close on the river bank. Arriving at the salient of the fort and mounting the parapet, the work showed itself as a double earthen parapet redoubt with interior slopes of masonry, the outer one being five feet six inches high, the latter five feet four only, with terrepleins of twenty feet. The exterior slope of the interior work rises from the terreplein of the outer one, and in the shoulder angle, land side, a covered way from the outer work communicates with the interior basement of the inner work. This is the only communication between the two works, except over the parapet. Mounting the inner parapet, the work showed itself as described with a two-foot masonry wall to protect the inner edge of the terreplein, or prevent accidents. The gorge is closed by a straight parapet, with

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gateway cut through, but no gate, an earthen ramp twelve feet wide leads on to the upper work. The whole of the interior consists of casemates for the use of the garrison and for stores. The berm is evidently the top of the outer wall of the casemates, which are about eight feet high, supported by walls from front to rear, with arched communication between them. At this place I was requested to go before the *Bogyee*, officer in command, who asked me my business, and on parting we shook hands. The ditch in rear was half knee deep in mud, over the knee in water, and about twelve feet wide. The garrison live in houses under the south and east faces of the work. The fort was quite empty, but there would be no difficulty in arming it from Mandalay. At this season it can only be attacked from the rear. Some twenty or fifty yards further up the river is a good landing and approach to the village of Thabyadan, but clearing the path first described with Artillery fire, the berm ought to be speedily gained and the rear of the work enfiladed, while a storming party goes over the parapet into the work itself. At this point no concentrated fire can be brought on the assailants: the attack has only to be forced home. Gaining the outer work and clearing it right and left, the rear of the column should storm the upper work. At this angle, on gaining the interior is the ramp to the basement. No assistance can come from within, and the rear of the fort and the gateway being held, the garrison is caught or driven over at the opposite side of the ditch. This fort should be levelled, there can be no object in garrisoning it: the country round is level. If any place is held it is Ava, which is too large to destroy. With this operation Mandalay is within grasp, seven miles distant.

The town of Amarapoora lies at the southern extremity of Mandalay, but it is about a mile inland, well away from the channel for steamers, and the country between it and Mandalay proper, is excessively bad and difficult for military operations, any attack on it would, therefore, entail loss of valuable time, whereas by leaving it alone, it would be turned. The expedition would find a good landing place at the Flotilla Company's Steamer's Wharf and King's Steamer's Wharf, four good direct roads leading up to the city. Such being the case, Amarapoora can be left alone, a landing effected at the wharves mentioned, and the embankment seized. At the wharves the outline represents the curtain of a bastion front, with its two short flanks. The flanks give flank defence along the whole length of the embankment north and south, while the curtain contains the entrance of and commands four roads, each not much less than one hundred feet in width. Having seized the curtain and entrenched it, any force can land and will find it a secure base, resting on the river, and with supplies assured. The force can now be divided into four columns and a reserve, the columns to be told off to A, B, C, and D roads, and named after them. The reserve to hold the base, and reinforce as required.

It is now necessary to consider the ground intervening between the base and the city. From the north embankment of Mandalay, a river by name Shway-ta-choung, runs through the centre and diagonally to

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the south-west and further corner of Mandalay, passing Amarapoora. Another called the Theng-sa-creek, breaks through the north embankment half way between the Shway-ta-choung and the western extremity, travels diagonally, nearly touching the embankment by B and C roads, and after crossing A road runs south-east into the Shway-ta-choung. Besides this, there are considerable backwaters lying between A, B, C, and D roads, which have to be crossed by means of bridges or bunds in more or less repair; C road is in good order for Heavy Artillery, B can be made so for Light Artillery, top planking will probably be all that is required, as the teak basements are all strong and generally good.

On preparation for an advance being made it is proposed (*vide* plan) to push A column out on the A road as far as the Shway-ta-choung, to hold the bridge and country from the base, and so protect the right flank of the advance from attack, and also take possession of the three bridges crossing the Choung to the north of A road, and so flank B's right. B, C, and D columns should also advance and seize the bridges on their roads over the Shway-ta-choung, B seizing the King's Bazaar beyond, and the bridge to the right, and holding the ground to C. C to hold the ground to D, while D column looks out for the left and left front, sending a force to seize the bridge over the Shway-ta-choung lying in prolongation of the north face of the city. The Attack having secured itself so far, must next advance as rapidly as possible direct on the city. D and C roads debouch on F road, one hundred feet wide, and running parallel to the city ditch 100 feet wide. Both D and C roads end opposite bridges crossing the ditch. One-third of each end of these bridges are masonry, the centre portion is wood, and may be partially destroyed.

The two gates of the city, west side, lie about half way between the ditch and city wall, and are covered by a masonry traverse twelve feet thick and 20 feet high.

F road, west side, is lined with wood houses. The D road crosses a mound about thirty feet high on the near side of the ditch, the top of this mound is said to be on a level with the top of the city wall. The north face front can here be enfiladed, and possibly a small force might be sent to close the bridge in the centre of the north face.

B road debouches on F road also, but in prolongation of the south face, the whole front of which, including the ditch, can be enfiladed from here, and the southern bridge commanded.

The force is now in position to attack the city. The object is to force the two gates in the western city wall. This wall is thirty feet high, seven feet being castellated with a solitary horizontal loophole in each battlement, but the intervals can be fired through. The wall is of good brick masonry,—authorities differ as to thickness. Major MacNeill gives it four feet all through, Mons. Bentabole (Secretary Foreign Affairs of the French Legation-Consulate), says it is eight feet thick, while Mons. Andrino, the Italian Consul, says it is fifteen feet thick; a considerable difference in opinion, but all agree in there being thirty feet of earthwork in rear. With the exception of a few ten-feet square buttresses projecting to the front, there is no attempt

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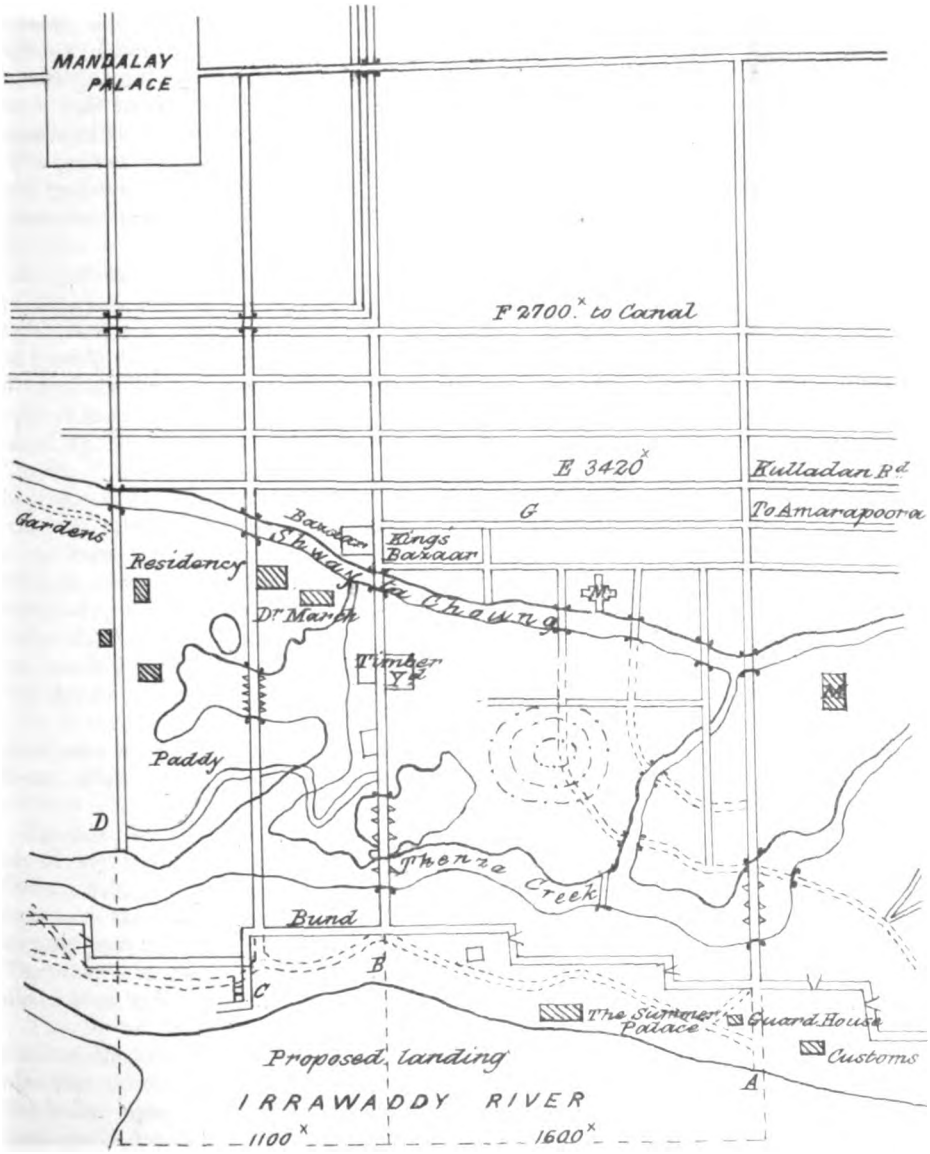

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at flank defence. These and the whole length of the city wall appear to be prepared for musketry defence only. The parapet above is probably not more than ten feet wide; notwithstanding MacNiell's authority, I am inclined to believe the wall to be fifteen feet thick at the base but not more than four feet at the top. It is hardly possible that a wall thirty feet high and only four feet thick could stand the pressure of earth against it.

The gateways are cut clean through the parapet and wall, gates of wood twelve inches thick are placed in the centre. Besides these gates, a three-bar barrier can be rolled across the front and rear of the gateways.

The gateways are topped with pagoda erections to give shelter from the sun, and perhaps for ornament. As a matter of course, I concluded that the parapets overhead were joined by a sort of bridge; but I could not see everything when I was passing through, and my informants tell me there is no means of crossing over the gateways. A flight of steps from the town level to the top of the parapet on one side of the gateway, usually the right side, leads on to the top of the parapet. The buttresses are also topped with pagoda roofs for ornament and shelter.

If the bridges are intact a fire should be kept up from under shelter of the town, on the whole length of the parapet wall, and the enemy's fire kept down. Whatever Mountain and Field Artillery has arrived, should fire on the buttress parapets near the gates, to destroy all shelter for flank defence; if the gateways can be blown in, the columns can be ordered to advance at once; in all probability it will be found that this cannot be attempted before dawn on the following day. The force in this case will entrench and screen itself with the means at hand, and a position for a breaching battery will be selected for the Heavy Battery, and arrangements made for its being brought up, and the best distribution for other Artillery will be decided on.

The Artillery force will probably consist of one Mountain Battery, one Heavy Battery, and two Field Batteries, these two to be sent from India. Four guns, if possible, should be on each flank to enfilade the fronts of the north and south faces and to prevent any attempt at turning movements from thence or to take the west face obliquely. The other four Field Artillery guns and six Mountain guns must be distributed to keep down the fire from the parapet.

The Naval Brigade will probably be able to supply guns for the flank of the base entrenchment—two on each flank north and south, also four more to assist the right flank defence along A road, two at the bridge over the Shway-ta-choung, and two in the position on the road up. A third Field Battery would be none too many for this column, and the four guns would be very useful in front.

The lateral distance between A and B roads is 1,600 yards; that between B and C as also between C and D is 550 yards.

The strength of the force will probably be detailed from India; but 6,000 men on Mandalay will be none too many, if it has to be beseiged, 4,000 more should be kept in Rangoon as a reserve to draw on.

It is to be remembered that a city of such a size cannot be occupied

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with a small force without great risk; and although it is said the Burmese will not fight, there is no certainty. It is evident they are provided with arms of the best description, and until thoroughly defeated by a force, showing them they cannot resist with effect, there will be no falling away from native authority—at least it cannot be counted on.

The advance may have to meet 30,000 men at Khooleygone and Minhla, and it is there most probably that the campaign, as far as fighting is concerned, will end; but the Burmese will have position, jungle, and all natural advantages in their favour there. It may also be necessary to move a column on Mandalay *viâ* Tounghoo; but this should be independent of the Irrawaddy Force and should not retard it, and which after establishing itself at Mandalay, would throw out a hand towards it, marching *viâ* Amarapoora.

To return: allowing the blowing in of the gates to have failed, the city wall must be breached and the bridges repaired, an intermediate bridge of casks or teak spars thrown across the ditch ready for an assaulting column. Then with a second attempt to blow in the gates, the three columns, on the explosion taking place should advance and force an entry, and immediately take possession of the top of the parapets. On this, two columns should be directed on the palace, west and east faces, the two entrances of which must be forced. The first is a teak stockade twenty-six feet high, ten-inch timbers quite close together. Field guns will cut an entry, after which the surrender of the Royal Family and Palace should be demanded. If not given over, there are two brick-walled enclosures to be forced.

Should at any time any friendlies offer their services, they should be directed to close the exit from Mandalay by the east gate, which this force cannot attempt without Cavalry. The north and south gates are practically closed by B and D columns.

Plans or sketches, made under instructions from me, are:—

1. Sagaing Redoubt and River. By Lieut. Brockman, R.A.
2. Thabyadan Fort. By Lieut. Goodwyn, R.E.
3. Mandalay, west face, showing landing, base of operations, and the line of advance, from Major MacNeill's Report, enlarged to twice the size by me, and copied by Lieut. Thorp, R.A. to all of whom I am much indebted for their cheerful assistance.

Trusting the scheme and report may meet with approval,

I have the honor to be,

Sir,

Your obedient Servant,

W. CAREY, Colonel, R.A.

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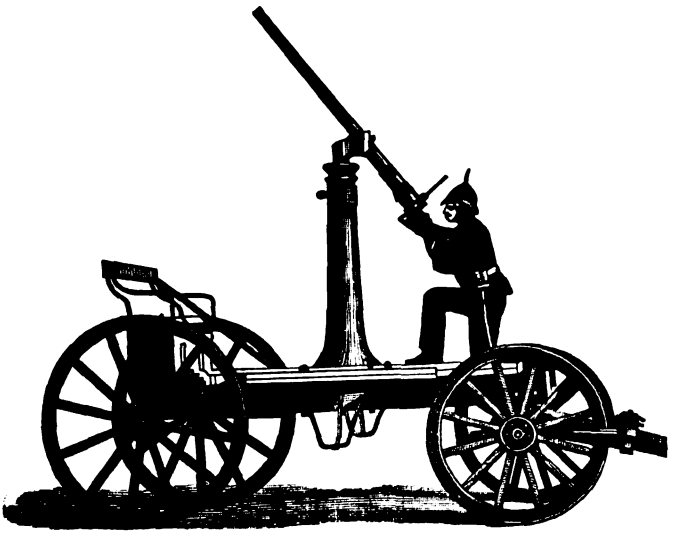
FIRING AT BALLOONS OF OBSERVATION.

BY

CAPTAIN W. H. H. WATERS, R.A.

(*From the "Russian Invalid" of 17 August, 1886*).

THE universal introduction of military balloons, and the successful aerial voyages carried out in Russia by the aeronautic sections of the Engineer Department, as well as by that of the Russian Imperial Technical Society, brings into great prominence the question of the infliction of serious danger to hostile aeronauts, at any rate while they are within the range of musketry or artillery fire. In view of this, it it will not be superfluous to call to mind the measures adopted by the Germans against the French balloons, which ascended during the siege of Paris in order to open communications between the Capital of France and those districts unoccupied by the enemy. On the first appearance of the French postal balloons, appeared an order from General Moltke to the manufactory of Krupp, for a weapon of sufficient range to hit a balloon. Such a weapon was constructed and soon made its appearance at Versailles, at that time the Head-Quarters of the



Germans. It consisted of a solid steel barrel, with a bore considerably larger than that of the rifles usually employed. The tube was strengthened by a wooden stock, which terminated in a butt-end, also of wood. On the tube was a sight for the direction of the weapon at the time of discharge, and for giving the elevation corresponding to the altitude

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at which the balloon was raised. The tube near its breech had trunnions in a bronze support, fastened to a special platform, provided with four wheels, with a seat for the man that was to fire it, and fitted for pair-horse draught. In order to fire this weapon and to give it the necessary angle of elevation, the man mounts on the platform of the carriage, places himself on one knee, and fires as he would from an ordinary rifle. It was decided at the German Head-Quarters during the Siege of Paris that on the appearance of a balloon from the beleagured town, the chain of sentries should communicate by telegraph the direction it might be following, when some wagons with these weapons would start in the direction and fire at the balloon. Thanks to this rule the Germans succeeded in firing at all the balloons which left Paris during the siege. All the aeronauts who ascended from the besieged town testify to this, and also to the fact that they heard the whizzing of the bullets, when they were detected at altitudes as high as 800 or 1000 mètres. From the newspaper "*La Nature*," where a description of the weapon was given, it appears that the balloon "Le Daguerre" ascended from Paris on 12th November, 1870, and was struck by such a number of bullets that the aeronauts were compelled, in consequence of the loss of gas, to descend rapidly at the small town of Ferrières, occupied by the Prussians, where they were taken prisoners. Although up till now facts testifying to the danger of serious injury being inflicted on balloons by fire are rather scarce, still one cannot deny the possibility of improvements in this direction. The fact of the infliction of injury by firing upon aeronauts, who have the means of ascending higher at any moment to any altitude, and thus escaping from those shooting at them, did not remain without results in France, in the arrangements of the French War Ministry; experiments were carried out in order to determine the altitude at which aeronauts might consider themselves completely safe from men firing at them from below. These trials were carried out with a captive balloon 4 mètres in diameter, and showed that a balloon of this size was completely safe from sharpshooters at an elevation of 400 mètres. It appeared from these trials that 12 good shots, armed with the Chassepôt, were unable in the course of a long period of time to inflict even slight injuries which would compel the aerostat to descend. However, one cannot but remark that these observations do not coincide with the information of the aeronauts who ascended from Paris during the siege of 1870, and who declared unanimously that, at a height of from 800 to 1000 mètres they heard the whistling of the balls fired at them by the Germans. We must therefore hope that subsequent experiments will explain more accurately at what altitude aeronauts may consider themselves quite safe from shots fired at them. It is very desirable that this height should be fixed, and it is important also because it is only by knowing it that really good results can be attained as regards the photographing of a locality where an enemy is posted. Indeed, it is only by conforming to this altitude that it is possible to select the object glass and the corresponding camera, in order, by their aid, to obtain exact representations of the locality occupied by the enemy—so important a point in a military aspect.

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REDUCTION OF BASHFORTH'S EXPERIMENTS BY INTERPOLATION.

BY

A. G. GREENHILL, M.A., AND LIEUT. F. L. NATHAN, R.A.

THE experiments conducted by Rev. F. Bashforth, B.D., in 1867–68 and again in 1878–80, are the foundation of the Gunnery Tables upon which the science of modern artillery practice is based.

The experiments consist essentially in recording, by means of Mr. Bashforth's Electric Chronograph, the instants of time at which a shot cuts a series of equidistant screens, and then in forming the first, second, third, &c., differences of these records in order to find the velocity and retardation of the shot, and thence the resistance of the air at all velocities required in Gunnery.

As the chronographs as constructed at present are not capable of recording to a greater accuracy than one ten-thousandths of a second, that is to four places of decimals, and as an error in the fourth decimal will sometimes affect the second differences of the time upon which the measure of the retardation depends to the extent of 10 per cent., we propose in this paper to apply Newton's and Lagrange's Interpolation Formulæ to the problem, as these formulæ do not require the operation of differencing.

1. Suppose, then, that

$$t_1,\ t_2,\ t_3,\ \ldots\ t_n$$

denote the instants of time as registered by the chronograph, at which screens at distances

$$s_1,\ s_2,\ s_3,\ \ldots\ s_n$$

from a fixed origin, say the muzzle of the gun, were cut by the shot.

Then, according to Lagrange's Interpolation Formula (Boole, *Finite Differences*, p. 38), we may assume that the time t at which the shot was at a distance s from the origin is given by,—

$$\begin{aligned} t = {} & \frac{*(s-s_2)}{*(s_1-s_2)}\,\frac{(s-s_3)}{(s_1-s_3)}\,\frac{\ldots\ldots}{\ldots\ldots}\,\frac{(s-s_n)}{(s_1-s_n)}\,t_1 \\ & + \frac{(s-s_1)}{(s_2-s_1)}\,\frac{*(s-s_3)}{*(s_2-s_3)}\,\frac{\ldots\ldots}{\ldots\ldots}\,\frac{(s-s_n)}{(s_2-s_n)}\,t_2 \\ & + \frac{(s-s_1)}{(s_3-s_1)}\,\frac{(s-s_2)}{(s_3-s_2)}\,\frac{*\ \ldots}{*\ \ldots}\,\frac{(s-s_n)}{(s_3-s_n)}\,t_3 \\ & + \ldots\ldots\ldots\ldots\ldots\ldots \\ & + \frac{(s-s_1)}{(s_n-s_1)}\,\frac{(s-s_2)}{(s_n-s_2)}\,\frac{\ldots\ldots}{\ldots\ldots}\,\frac{(s-s_{n-1})}{(s_n-s_{n-1})}\,*\,t_n\,; \end{aligned}$$

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a formula which agrees in giving

$$t = t_1 \text{ when } s = s_1,$$
$$t = t_2 \quad ,, \quad s = s_2,$$
$$t = t_3 \quad ,, \quad s = s_3,$$
$$\cdots\cdots\cdots$$
$$t = t_n \quad ,, \quad s = s_n;$$

the * showing the position of the omitted vanishing factors.

Then if v denotes the velocity and f the retardation at the distance s,

$$v = \frac{ds}{dt}, \; f = -\frac{d^2s}{dt^2} = \frac{d^2t}{ds^2}\left(\frac{ds}{dt}\right)^3 = \frac{d^2t}{ds^2}v^3,$$

so that

$$\frac{1}{v} = \frac{dt}{ds}, \text{ and } \frac{f}{v^3} = \frac{d^2t}{ds^2},$$

are obtained by differentiating once and twice.

2. Now as it is only necessary to determine the velocity and the corresponding retardation at any given screen, let us assume that the origin from which the distance s is measured is placed at the given screen, and that the other screens are a given equal distance l feet apart; then if there are m screens before and n screens after the given origin, the above interpolation formula can be written,—

$$t = -\sum_{p=1}^{p=m}\left(1+\frac{1}{m}\frac{s}{l}\right)\left(1+\frac{1}{m-1}\frac{s}{l}\right)\cdots\left(1+\frac{1}{p+1}\frac{s}{l}\right)*\left(1+\frac{1}{p-1}\frac{s}{l}\right)\cdots$$
$$\cdots\left(1+\frac{s}{l}\right)\frac{s}{l}\left(1-\frac{s}{l}\right)\cdots\left(1-\frac{1}{n}\frac{s}{l}\right)C_{-p}t_{-p}$$
$$+\left(1+\frac{1}{m}\frac{s}{l}\right)\left(1+\frac{1}{m-1}\frac{s}{l}\right)\cdots\left(1+\frac{s}{l}\right)*\left(1-\frac{s}{l}\right)\cdots\left(1-\frac{1}{n}\frac{s}{l}\right)t_0$$
$$+\sum_{q=1}^{q=n}\left(1+\frac{1}{n}\frac{s}{l}\right)\left(1+\frac{1}{m-1}\frac{s}{l}\right)\cdots\left(1+\frac{s}{l}\right)\frac{s}{l}\left(1-\frac{s}{l}\right)\cdots$$
$$\cdots\left(1-\frac{1}{q-1}\frac{s}{l}\right)*\left(1-\frac{1}{q+1}\frac{s}{l}\right)\cdots\left(1-\frac{1}{n}\frac{s}{l}\right)C_qt_q$$

where t_{-p} is the time at which the pth screen before the origin is cut,
,, t_q ,, ,, qth ,, after ,, ,, ;
and the formula agrees in giving

$$t = t_{-p} \quad \text{when } s = -pl,$$
$$t = t_0 \quad \text{when } s = 0,$$
$$t = t_q \quad \text{when } s = ql;$$

provided C_{-p} and C_q are suitably chosen; and we shall then find that

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$$C_{-p} = \frac{(-1)^{p-1}\quad m!\ n!}{p\,(m-p)!\quad (n+p)!},$$

$$C_q = \frac{(-1)^{q-1}\quad m!\ n!}{q\,(m+q)!\quad (n-q)!};$$

or

$$C_{-p} = \frac{(-1)^{p-1}}{p}\,\frac{(m-p+1)}{(n+1)}\,\frac{(m-p+2)}{(n+2)}\,\ldots\,\frac{m}{(n+p)},$$

$$C_q = \frac{(-1)^{q-1}}{q}\,\frac{(n-q+1)}{(m+1)}\,\frac{(n-q+2)}{(m+2)}\,\ldots\,\frac{n}{(m+q)}.$$

Now, as we only require $\frac{dt}{ds}$ and $\frac{d^2t}{ds^2}$ for the value $s = 0$, instead of differentiating, which would be very complicated, let us suppose that the above formula for t in terms of s is expanded in ascending powers of s as far as s^2 in the form

$$t = t_0 + as + bs^2 + \ldots\ldots\ ;$$

then when $s = 0$, $\frac{dt}{ds} = a$, and $\frac{d^2t}{ds^2} = 2b$.

3. Collecting the coefficients of s we shall find that

$$al = -\sum_{p=1}^{p=m} C_{-p}t_{-p} + (M-N)\,t_0 + \sum_{q=1}^{q=n} C_q t_q,$$

where M denotes the harmonic progression,

$$1 + \tfrac{1}{2} + \tfrac{1}{3} + \ldots\ldots + \frac{1}{m},$$

the sum of the reciprocals of the first m numbers;
and similarly N denotes

$$1 + \tfrac{1}{2} + \tfrac{1}{3} + \ldots\ldots + \frac{1}{n}.$$

Collecting the coefficients of s^2 we shall find that

$$bl^2 = -\sum_{p=1}^{p=m}\left(M - N - \frac{1}{p}\right)C_{-p}t_{-p}$$
$$+ \tfrac{1}{2}\left\{(M-N)^2 - \sum_{p=1}^{p=m}\frac{1}{p^2} - \sum_{q=1}^{q=n}\frac{1}{q^2}\right\}t_0$$
$$+ \sum_{q=1}^{q=n}\left(M - N + \frac{1}{q}\right)C_q\,t_q.$$

Now the values of al and bl^2, being independent of the epoch from which the time is measured, must be functions of $t_0 - t_{-p}$ and $t_q - t_0$; so that we may put

$$al = \sum_{p=1}^{p=m} C_{-p}(t_0 - t_{-p}) + \sum_{q=1}^{q=n} C_q(t_q - t_0),$$

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leading to the following curious algebraical identity, pointed out by Captain P. A. MacMahon, R.A.,

$$\sum_{p=1}^{p=m} C_{-p} - \sum_{q=1}^{q=n} C_q = M - N,$$

or
$$\frac{m}{n+1} - \tfrac{1}{2}\frac{m(m-1)}{(n+1)(n+2)} + \tfrac{1}{3}\frac{m(m-1)(m-2)}{(n+1)(n+2)(n+3)} \cdots\cdots$$
$$- \frac{n}{m+1} - \tfrac{1}{2}\frac{n(n-1)}{(m+1)(m+2)} - \tfrac{1}{3}\frac{n(n-1)(n-2)}{(m+1)(m+2)(m+3)} \cdots\cdots$$
$$= 1 + \tfrac{1}{2} + \tfrac{1}{3} + \cdots\cdots + \frac{1}{m} - \left(1 + \tfrac{1}{2} + \tfrac{1}{3} + \cdots\cdots + \frac{1}{n}\right) \quad \text{(A)}$$

Similarly δl^2, being a function of the differences $t_0 - t_{-p}$ and $t_q - t_0$, can be written

$$\delta l^2 = \sum_{p=1}^{p=m} \left(M - N - \frac{1}{p}\right) C_{-p}(t_0 - t_{-p})$$
$$+ \sum_{q=1}^{q=n} \left(M - N + \frac{1}{q}\right) C_q (t_q - t_0)$$
$$= (M - N)\, al$$
$$- \sum_{p=1}^{p=m} \frac{1}{p} C_{-p}(t_0 - t_{-p}) + \sum_{q=1}^{q=n} \frac{1}{q} C_q (t_q - t_0),$$

involving another algebraical identity,

$$\Sigma\left(M - N - \frac{1}{p}\right) C_{-p} - \Sigma\left(M - N + \frac{1}{q}\right) C_q$$
$$= \tfrac{1}{2}\left\{(M-N)^2 - \Sigma\frac{1}{p^2} - \Sigma\frac{1}{q^2}\right\}$$

or
$$\Sigma\frac{1}{p} C_{-p} + \Sigma\frac{1}{q} C_q$$
$$= (M - N)(\Sigma C_{-p} - \Sigma C_q)$$
$$- \tfrac{1}{2}\left\{(M-N)^2 \Sigma\frac{1}{p^2} - \Sigma\frac{1}{q^2}\right\}$$
$$= \tfrac{1}{2}\left\{(M-N)^2 + \Sigma\frac{1}{p^2} + \Sigma\frac{1}{q^2}\right\},$$

or
$$\sum_{p=1}^{p=m} \frac{(-1)^{p-1} m!\, n!}{p^2 (m-p)!\,(n+p)!} + \sum_{q=1}^{q=n} \frac{(-1)^{q-1} m!\, n!}{q^2 (m+q)!\,(n-q)!}$$
$$= \tfrac{1}{2}\left(1 + \tfrac{1}{2} + \tfrac{1}{3} + \ldots + \frac{1}{m} - 1 - \tfrac{1}{2} - \ldots - \frac{1}{n}\right)^2$$
$$+ \tfrac{1}{2}\sum_{p=1}^{p=m}\frac{1}{p^2} + \tfrac{1}{2}\sum_{q=1}^{q=n}\frac{1}{q^2} \cdots\cdots\cdots\cdots\cdots \quad \text{(B)}$$

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4. Consequently, using Lagrange's interpolation formula, instead of differencing, we find that

$$al = \sum_{p=1}^{p=m} \frac{(-1)^{p-1}(m-p+1)(m-p+2)\ldots m}{p \quad (n+1) \quad (n+2) \ldots (n+p)}(t_0 - t_{-p})$$
$$+ \sum_{q=1}^{q=n} \frac{(-1)^{q-1}(n-q+1)(n-q+2)\ldots n}{q \quad (m+1) \quad (m+2) \ldots (m+q)}(t_q - t_0);$$
$$bl^3 = (M-N)\,al$$
$$- \sum_{p=1}^{p=m} \frac{(-1)^{p-1}(m-p+1)(m-p+2)\ldots m}{p^2 \quad (n+1) \quad (n+2) \ldots (n+p)}(t_0 - t_{-p})$$
$$+ \sum_{q=1}^{q=n} \frac{(-1)^{-1}(n-q+1)(n-q+2)\ldots n}{q^2 \quad (m+1) \quad (m+2) \ldots (m+q)}(t_q - t_0);$$

and then
$$a = \frac{1}{v},$$
$$2bv^3 = \frac{d^2}{W} K \left(\frac{v}{1000}\right)^3$$
or
$$K = (1000)^3 \frac{W}{d^2} 2b,$$

determining Mr. Bashforth's coefficient K, d denoting the diameter of the projectile in inches, and W its weight in pounds.

Also l denotes the distance between the screens in feet, m the number of screens before and n the number of screens after the given screen at which a and b are to be determined.

5. The following numerical applications of the above theory have been worked out from data taken from the "*Final Report on Experiments made with the Bashforth Chronograph to determine the Resistance of the Air to the Motion of Elongated Projectiles, 1878–80;*" and the results are compared with those of Mr. Bashforth, obtained by the method of differencing.

Report VIII., Table I., pages 12 to 16, gives the chronograph time records of the passage of the projectile through equidistant screens 150 feet apart.

Round 479 of the 12th of March, 1879, is a round much used by the Rev. F. Bashforth in computing the value of K; taking this round, then, and applying to it the interpolation formula, the velocity at the 6th screen is determined as follows:—

Here $m = 5$, and $n = 6$.

Also

t_{-5}	= ·0000 and	$t_0 - t_{-5}$	= ·3439
t_{-4}	= ·0666	$t_0 - t_{-4}$	= ·2773
t_{-3}	= ·1343	$t_0 - t_{-3}$	= ·2096
t_{-2}	= ·2031	$t_0 - t_{-2}$	= ·1408
t_{-1}	= ·2729	$t_0 - t_{-1}$	= ·0710
t_0	= ·3439		
t_1	= ·4159	$t_1 - t_0$	= ·0720
t_2	= ·4891	$t_2 - t_0$	= ·1452
t_3	= ·5633	$t_3 - t_0$	= ·2194
t_4	= ·6387	$t_4 - t_0$	= ·2948
t_5	= ·7151	$t_5 - t_0$	= ·3712
t_6	= ·7927	$t_6 - t_0$	= ·4488

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Then

$$al = + \frac{5!\,6!}{1.\,4!\,7!}(t_0 - t_{-1}) = \frac{5}{7}(\cdot0710) = \cdot050714$$

$$- \frac{5!\,6!}{2.\,3!\,8!}(t_0 - t_{-2}) = \frac{5}{28}(\cdot1408) = \cdot025142$$

$$+ \frac{5!\,6!}{3.\,2!\,9!}(t_0 - t_{-3}) = \frac{5}{126}(\cdot2096) = \cdot008317$$

$$- \frac{5!\,6!}{4.\,1!\,10!}(t_0 - t_{-4}) = \frac{1}{168}(\cdot2773) = \cdot001650$$

$$+ \frac{5!\,6!}{5.\,11!}(t_0 - t_{-5}) = \frac{1}{2310}(\cdot3439) = \cdot000148$$

$$+ \frac{5!\,6!}{1.\,6!\,5!}(t_1 - t_0) = (\cdot0720) = \cdot0720$$

$$- \frac{5!\,6!}{2.\,7!\,4!}(t_2 - t_0) = \frac{5}{14}(\cdot1452) = \cdot051857$$

$$+ \frac{5!\,6!}{3.\,8!\,3!}(t_3 - t_0) = \frac{5}{42}(\cdot2194) = \cdot026119$$

$$- \frac{5!\,6!}{4.\,9!\,2!}(t_4 - t_0) = \frac{5}{168}(\cdot2948) = \cdot008774$$

$$+ \frac{5!\,6!}{5.\,10!\,1!}(t_5 - t_0) = \frac{1}{210}(\cdot3712) = \cdot001767$$

$$- \frac{5!\,6!}{6.\,11!}(t_6 - t_0) = \frac{1}{2772}(\cdot4488) = \cdot000162$$

Therefore

$$\begin{array}{rrr} al = & + \cdot050714 & - \cdot025142 \\ & \cdot008317 & \cdot001650 \\ & \cdot000148 & \cdot051857 \\ & \cdot072000 & \cdot008774 \\ & \cdot026119 & \cdot000162 \\ & \cdot001767 & \\ & \hline \cdot159065 & - \cdot087585 \end{array}$$

$al = \cdot07148$

Therefore $\log al = \bar{2}\cdot8541845$

and $\log l = 2\cdot1760913$

Hence $\log v = 3\cdot3219068$

and therefore $v = 2098\cdot5$

By a similar process the velocities at the other screens may be found. The following table compares the Rev. F. Bashforth's results of differencing and those obtained by the above interpolation method :—

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SCREENS 150 FEET APART.

Screens ...	1	2	3	4	5	6	7	8	9	10	11	12
Bashforth ...	2271	2234	2199	2164	2131	2098	2066	2035	2006	1977	1948	1921
Interpolation	1979	2272	2188	2168	2129	2098	2067	2033	2009	1969	1980	1695

The above table shows that by the interpolation method the velocities for the first and last two screens are decidedly irregular, probably from the existence of points of inflexion in the interpolation curve.

For calculating the value of K for the 6th screen of round 479, that is for a velocity of about 2100 f.s., we have :—

$$\begin{aligned}
bl^2 = &-\tfrac{1}{6}\,al && = -\cdot011913\\
&-\frac{5!\,6!}{1.\,4!\,7!}(t_0 - t_{-1}) && = -\cdot050714\\
&+\frac{5!\,6!}{2^2.\,3!\,8!}(t_0 - t_{-2}) && = +\cdot012571\\
&-\frac{5!\,6!}{3^2.\,2!\,9!}(t_0 - t_{-3}) && = -\cdot002772\\
&+\frac{5!\,6!}{4^2.\,1!\,10!}(t_0 - t_{-4}) && = +\cdot000412\\
&-\frac{5!\,6!}{5^2.\,11!}(t_0 - t_{-5}) && = -\cdot000029\\
&+\frac{5!\,6!}{1.\,6!\,5!}(t_1 - t_0) && = +\cdot072000\\
&-\frac{5!\,6!}{2^2.\,7!\,4!}(t_2 - t_0) && = -\cdot025928\\
&+\frac{5!\,6!}{3^2.\,8!\,3!}(t_3 - t_0) && = +\cdot008706\\
&-\frac{5!\,6!}{4^2.\,9!\,2!}(t_4 - t_0) && = -\cdot002194\\
&+\frac{5!\,6!}{5^2.\,10!\,1!}(t_5 - t_0) && = +\cdot000353\\
&-\frac{5!\,6!}{6^2.\,11!}(t_6 - t_0) && = -\cdot000027
\end{aligned}$$

Therefore

$$\begin{aligned}
bl^2 = &+\cdot012571 && -\cdot011913\\
&+\cdot000412 && -\cdot050714\\
&+\cdot072000 && -\cdot002772\\
&+\cdot008706 && -\cdot000029\\
&+\cdot000353 && -\cdot025928\\
& && -\cdot002194\\
& && -\cdot000027\\
&+\cdot094043 && -\cdot093577\\
= &\ \cdot000465\,.
\end{aligned}$$

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$$\therefore \log b l^2 = \bar{4}\cdot 6674530$$
$$\log l^2 = 4\cdot 3521826$$
$$\log b = \bar{8}\cdot 3152704.$$
$$\therefore \quad b = \cdot 000000020667$$
$$\therefore \quad 2b = \cdot 000000041334.$$

And $d = 6$, $W = 50$, so that

$$K = \frac{50}{36} \times 1000^3 \times \cdot 000000041334$$

$$\log \quad 50 = 1\cdot 6989700$$
$$\log 1000^3 = 9\cdot 0000000$$
$$\log \quad 2b = \bar{8}\cdot 6163074$$
$$3\cdot 3152774$$
$$\log \quad 36 = 1\cdot 5563025$$
$$\therefore \log \quad K = 1\cdot 7589749$$
$$\therefore \quad K = 57\cdot 408.$$

7. Neglecting the first and second, tenth and eleventh screens, Round 473 gives the following velocities :—

Screens	3	4	5	6	7	8	9
Bashforth	2090	2053	2019	1987	1956	1927	1899
Interpolation... ...	2084	2055	2020	1987	1956	1922	1911

Here, when an odd number of screen records has been employed, the agreement of the two methods is much more close than in the above reduction of round 479, where an even number of screen records was taken.

Similar calculations showed that the interpolation method failed to give correct results whenever an even number of screens was taken.

The values of K, for instance, corresponding to the velocities at the other screens of round 479, were found in like manner by the interpolation method. The following table gives the Rev. F. Bashforth's mean values for K at the different velocities, also the particular values for Round 479, and the values of K as determined by the interpolation formula :—

Screens	4	5	6	7	8	9	10
Velocities	2160	2130	2100	2070	2040	2010	1980
Mean value of K ...	66·3	65·1	68·8	66·3	65·8	66·6	66·9
Value for round 479 ...	67·8	67·8	67·9	67·8	68·5	68·3	68·4
Interpolation value ...	99·4	76·9	57·4	223·8	—	—	—

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This great discrepancy is due to the existence of points of inflexion on the curve whose equation connecting t the ordinate and s the abscissa is given by the interpolation formula.

When the number of screens is even, the curve is of odd degree, and must have an odd number of points of inflexion; but if the number of screens is odd, the curve is of even degree, and may have no points of inflexion.

8. Henceforth, then, in interpolation, we shall always employ an odd number of screens, and it will serve as a convenient check on the calculations and a guide to the extent of the accuracy obtained by taking more and more screen records, if we suppose the given screen the middle one of an odd number of screens, and investigate the different values of al and bl^2 obtained by supposing it the middle one of (i) three (ii) five (iii) seven (iv) nine (v) eleven, &c., screens.

This is equivalent to putting $m = n$ in the above interpolation formula, and then

(i) for three screens, $m = n = 1$,

and $$t = t_0 + as + bs^2,$$

whence $$al = \tfrac{1}{2}(t_1 - t_{-1}),$$

$$bl^2 = \tfrac{1}{2}(t_1 - 2t_0 + t_{-1});$$

(ii) for five screens, $m = n = 2$,

and $$al = \frac{2}{1.3}(t_1 - t_{-1}) - \frac{1.2}{2.3.4}(t_2 - t_{-2})$$

$$= \tfrac{2}{3}(t_1 - t_{-1}) - \tfrac{1}{12}(t_2 - t_{-2}),$$

$$bl^2 = \frac{2}{1.3}(t - 2t_0 + t_{-1}) - \frac{1.2}{2^2.3.4}(t_2 - 2t_0 + t_{-2})$$

$$= \tfrac{2}{3}(t_1 - 2t_0 + t_{-1}) - \tfrac{1}{24}(t_2 - 2t_0 + t_{-2});$$

(iii) for seven screens, $m = n = 3$,

$$al = \frac{3}{1.4} Dt_1 - \frac{2.3}{2.4.5} Dt_2 + \frac{1.2.3}{3.4.5.6} Dt_3,$$

$$bl^2 = \frac{3}{1^2.4} D^2t_1 - \frac{2.3}{2^2.4.5} D^2t_2 + \frac{1.2.3}{3^2.4.5.6} D^2t_3,$$

using the notation Dt_p to denote $t_p - t_{-p}$,

and D^2t_p to denote $t_p - 2t_0 + t_{-p}$;

and so on for nine, eleven, &c., screens, the general formula for $2m + 1$ screens being

$$al = \sum_{p=1}^{p=m} \frac{(-1)^{p-1}(m-p+1)(m-p+2)\ldots m}{p \quad (m+1) \quad (m+2)\ldots(m+p)}(t_p - t_{-p}),$$

$$bl^2 = \sum_{p=1}^{p=m} \frac{(-1)^{p-1}(m-p+1)(m-p+2)\ldots m}{p^2 \quad (m+1) \quad (m+2)\ldots(m+p)}(t_p - 2t_0 + t_{-p}).$$

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These values of al and and bl^2 are readily obtained from Newton's original Interpolation Formula (*Methodus Differentialis, 1711*)

$$t = c_{-m}t_{-m} + \ldots + c_{-1}t_{-1} + c_0t_0 + c_1t_1 + \ldots + c_mt_m,$$

where the $c's$ are functions of s, chosen so that $s = ql$ makes $c_q = 1$, and all the other $c's$ vanish.

The simplest way in which this can be done rationally and integrally is by writing

$$t = \frac{s\,(l^2 - s^2)\,(4l^2 - s^2) \ldots (m^2l^2 - s^2)}{2m!\ l^{2m}}$$

$$\left(\frac{v_nt_0}{s} - \frac{v_{n-1}t_1}{s-l} - \frac{v_{n-1}t_{-1}}{s+l} + \ldots\ldots \pm \frac{t_n}{s-ml} \pm \frac{t_{-n}}{s+m^2}\right)$$

where v_n is the coefficient of x^n in the binomial expansion of $(1+x)^{2m}$. (*Report on the Present State of Knowledge of the Application of Quadratures and Interpolation to Actual Data*; by C. W. Merrifield, F.R.S., 1880).

9. Let us apply the formula to the 6th screen of round 479; here

$$t_0 = 0{\cdot}3439,$$

$t_{-1} = {\cdot}2729,$	$t_1 = {\cdot}4159,$
$t_{-2} = {\cdot}2031,$	$t_2 = {\cdot}4891,$
$t_{-3} = {\cdot}1343,$	$t_3 = {\cdot}5633,$
$t_{-4} = {\cdot}0666,$	$t_4 = {\cdot}6387,$
$t_{-5} = {\cdot}0000,$	$t_5 = {\cdot}7151,$

$$t_6 = 0{\cdot}7927.$$

Then

$Dt_1 = {\cdot}1430,$	$D^2t_1 = {\cdot}0010,$
$Dt_2 = {\cdot}2860,$	$D^2t_2 = {\cdot}0044,$
$Dt_3 = {\cdot}4290,$	$D^2t_3 = {\cdot}0098,$
$Dt_4 = {\cdot}5721,$	$D^2t_4 = {\cdot}0175,$
$Dt_5 = {\cdot}7151,$	$D^2t_5 = {\cdot}0273.$

Therefore at the 6th screen

(i) using three screens

$$al = {\cdot}0715,$$
$$bl^2 = {\cdot}0005;$$

(ii) using five screens

$$al = \tfrac{4}{3} \times {\cdot}1430 - \tfrac{1}{12} \times {\cdot}2860 = {\cdot}0715,$$
$$bl^2 = \tfrac{4}{3} \times {\cdot}0010 - \tfrac{1}{24} \times {\cdot}0044 = {\cdot}000483;$$

(iii) using seven screens

$$al = \tfrac{3}{4} \times {\cdot}1430 - \tfrac{3}{20} \times {\cdot}2860 + \tfrac{1}{60} \times {\cdot}4290 = {\cdot}0715,$$
$$bl^2 = \tfrac{3}{4} \times {\cdot}0010 - \tfrac{3}{40} \times {\cdot}0044 + \tfrac{1}{180} \times {\cdot}0098 = {\cdot}000474;$$

(iv) using nine screens

$$al = {\cdot}0715, \text{ as before},$$
$$bl^2 = {\cdot}00042815.$$

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We see, then, that while the value of al remains the same however many screens are employed for its determination, the value of bl^2 is perceptibly different, and this is the most important part to be determined, considering its bearing on the resistance of the air.

10. Now let us try the effect of supposing that the chronograph records are given to three places of decimals only, using the nearest figure;

Then
$$t_0 = 0{\cdot}416,$$
$$t_{-1} = 0{\cdot}273, \quad t_1 = 0{\cdot}416,$$
$$t_{-2} = 0{\cdot}203, \quad t_2 = 0{\cdot}489,$$
$$t_{-3} = 0{\cdot}134, \quad t_3 = 0{\cdot}563,$$
$$t_{-4} = 0{\cdot}067, \quad t_4 = 0{\cdot}639,$$
$$t_{-5} = 0{\cdot}000, \quad t_5 = 0{\cdot}715,$$
$$t_6 = 0{\cdot}793.$$

Then
$$Dt_1 = {\cdot}143, \quad D^2t_1 = {\cdot}001,$$
$$Dt_2 = {\cdot}286, \quad D^2t_2 = {\cdot}004,$$
$$Dt_3 = {\cdot}429, \quad D^2t_3 = {\cdot}009,$$
$$Dt_4 = {\cdot}572, \quad D^2t_4 = {\cdot}018,$$
$$Dt_5 = {\cdot}715, \quad D^2t_5 = {\cdot}027,$$

Then (i)
$$al = {\cdot}0715,$$
$$bl^2 = {\cdot}0005;$$

(ii)
$$al = {\cdot}0715,$$
$$bl^2 = {\cdot}0005;$$

(iii)
$$al = {\cdot}0715,$$
$$bl^2 = {\cdot}0005;$$

(iv)
$$al = {\cdot}0715,$$
$$bl^2 = {\cdot}0004982;$$

so that in this case greater regularity is obtained in the reduction with three instead of four figures in the decimals of the same records.

11. Taking the average value of al and bl^2 as
$$al = {\cdot}0715,$$
$$bl^2 = {\cdot}0005;$$
then since
$$l = 150,$$
$$\log l = 2{\cdot}17609,$$
$$\log al = \bar{2}{\cdot}85431,$$
$$\log v = 3{\cdot}32178,$$
$$v = 2097{\cdot}9:$$

Bashforth gives 2098.

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Again,

$$\log b l^2 = \bar{4}\cdot 69897,$$
$$\log l^2 = 4\cdot 35218,$$
$$\log b = \bar{8}\cdot 34679,$$
$$\log 2 = \cdot 30103,$$
$$\log 2b = \bar{8}\cdot 64782.$$

Now

$$K = (1000)^3 \frac{W}{d^2} 2b;$$

and here

$$W = 50,\ d = 6;$$
$$\log d = \cdot 77815,$$
$$\log d^2 = 1\cdot 55630,$$
$$\log W = 1\cdot 69897,$$
$$\log \frac{W}{d^2} = \cdot 14267,$$
$$\log (1000)^3\, 2b = 1\cdot 64782,$$
$$\log K = 1\cdot 79049,$$
$$K = 61\cdot 73.$$

Turning to pp. 31 and 32 of Bashforth's "*Final Report*," we find against round 479, at velocity

$$v = 2090, \quad K = 68\cdot 3,$$
$$v = 2100, \quad K = 68\cdot 8.$$

12. Our value of K has, however, not yet been reduced to the standard density of the air.

On March 12th, 1879, the date of round 479, the barometer was at 29·4 inches, and the wet and dry bulb thermometers at 40° and 43° F., or a mean temperature of 41·5° F.

Reduced to a standard height of barometer of 30 inches, and a standard temperature of 62° F., the value of K will be

$$K = 61\cdot 73 \times \frac{30}{29\cdot 4} \times \frac{461 + 62}{461 + 41\cdot 5}$$

— 461 being the absolute zero on Fahrenheit's scale; and therefore $K = 65\cdot 55$, which is still considerably less than Mr. Bashforth's value; and the other values of bl^2, obtained from the interpolation formula, being less than ·0005 will give still less values of K.

13. Let us now apply the formulæ of Arts. 4 and 8 to some of the screen records of Round 473, and compare the results obtained with those given in Mr. Bashforth's report.

Round 473, third screen; then to three places of decimals,

$$t_0 = 0\cdot 141,$$
$$t_{-1} = 0\cdot 070, \quad t_1 = 0\cdot 213,$$
$$t_{-2} = 0\cdot 000, \quad t_2 = 0\cdot 287,$$
$$Dt_1 = \cdot 143, \quad D^2 t_1 = \cdot 001,$$
$$Dt_2 = \cdot 287, \quad D^2 t_2 = \cdot 005,$$

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so that

(i) $al = \cdot0715$,
$bl^2 = \cdot0005$;

(ii) $al = \cdot0714$,
$bl^2 = \cdot000458$;

but with four places of decimals, we shall find

(i) $al = \cdot0718$,
$bl^2 = \cdot0007$;

(ii) $al = \cdot071808$,
$bl^2 = \cdot0007208$.

14. Again, round 473, fourth screen,

$$t_0 = 0{\cdot}213,$$
$$t_{-1} = 0{\cdot}141, \quad t_1 = 0{\cdot}287,$$
$$t_{-2} = 0{\cdot}070, \quad t_2 = 0{\cdot}362,$$
$$t_{-3} = 0{\cdot}000, \quad t_3 = 0{\cdot}438,$$

to three places of decimals.

Then

$$Dt_1 = \cdot146, \quad D^2t_1 = \cdot002,$$
$$Dt_2 = \cdot292, \quad D^2t_2 = \cdot006,$$
$$Dt_3 = \cdot438, \quad D^2t_3 = \cdot012.$$

Therefore

(i) from three screens

$$al = \cdot073, \quad bl^2 = \cdot001;$$

(ii) from five screens

$$al = \cdot073, \quad bl^2 = \cdot00011.$$

(iii) with seven screens

$$al = \cdot073, \quad bl^2 = \cdot0011.$$

But to four places of decimals, fourth screen,

$$t_0 = 0{\cdot}2135,$$
$$t_{-1} = 0{\cdot}1410, \quad t_1 = 0{\cdot}2871,$$
$$t_{-2} = 0{\cdot}0699, \quad t_2 = 0{\cdot}3620,$$
$$t_{-3} = 0{\cdot}0000, \quad t_3 = 0{\cdot}4381;$$

so that

$$Dt_1 = \cdot1461, \quad D^2t_1 = \cdot0011,$$
$$Dt_2 = \cdot2921, \quad D^2t_2 = \cdot0049,$$
$$Dt_3 = \cdot4381, \quad D^2t_3 = \cdot0111.$$

Therefore

(i) from three screens

$$al = \cdot07305, \quad bl^2 = \cdot00055;$$

(ii) from five screens

$$al = \cdot07306, \quad bl^2 = \cdot00053.$$

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15. Again, with round 473, fourth screen, take all eleven screen records into account, then we must put $m = 3$, $n = 7$; and then, from the interpolation formula, taking the screen records to four places of decimals

$$al = \frac{1.2.3}{3.8.9.10} \times \cdot0725 = + 0\cdot0271875$$

$$- \frac{2.3}{2.8.9} \times \cdot1436 = - 0\cdot005983$$

$$+ \frac{3}{1.8} \times \cdot2135 = + 0\cdot000593$$

$$+ \frac{7}{1.4} \times \cdot0736 = + 0\cdot1288$$

$$- \frac{6.7}{2.4.5} \times \cdot1485 = - 0\cdot155925$$

$$+ \frac{5.6.7}{3.4.5.6} \times \cdot2246 = + 0\cdot131016$$

$$- \frac{4.5.6.7}{4.4.5.6.7} \times \cdot3019 = - 0\cdot075475$$

$$+ \frac{3.4.5.6.7}{5.4.5.6.7.8} \times \cdot3804 = + 0\cdot02853$$

$$- \frac{2.3.4.5.6.7}{6.4.5.6.7.8.9} \times \cdot4599 = - 0\cdot0063875$$

$$+ \frac{1.2.3.4.5.6.7}{7.4.5.6.7.8.9} \times \cdot5406 = + 0\cdot00064357$$

so that

$$al = 0\cdot07299962$$
$$= \cdot073, \text{ say; making}$$
$$v = 2054\cdot8.$$

Similarly, by substitution in the formula, we shall find the corresponding value of

$$bl^2 = \cdot00053,$$

giving

$$K = 65\cdot33.$$

16. In a similar manner, for round 473, and the fifth screen, we shall find, putting $m = 4$, $n = 6$,

$$al = \cdot07424844,$$
$$bl^2 = \cdot000674,$$

giving

$$v = 2020$$
$$K = 83\cdot18.$$

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Taking, however, the fifth screen as the middle one of

(i) three screens

$$al = \cdot 07425$$
$$bl^3 = \cdot 00065;$$

(ii) five screens

$$bl^3 = \cdot 0006624;$$

(iii) seven screens

$$bl^3 = \cdot 0006692.$$

With the lowest value of bl^3, viz.,

$$bl^3 = \cdot 00065$$
$$\log bl^3 = \bar{4}\cdot 81291,$$
$$\log l^2 = 4\cdot 35218,$$
$$\log b = \bar{8}\cdot 46073,$$
$$\log 2 = \cdot 30103,$$
$$\log (1000)^3 \frac{W}{d^3} = 9\cdot 14267,$$
$$\log K = 1\cdot 90443,$$
$$K = 80\cdot 17.$$

The following table exhibits the results obtained by working out the values of al and bl^3 in articles 13 to 16, and comparing the values of v and k, with those of Mr. Bashforth.

Screen.		Bashforth.	Article 8. Three places of decimals.		Article 8. Four places of decimals.		Article 4.
			(i).	(ii).	(i).	(ii).	
3rd.	v	2090	2089	2089	2089	2101	2084
	K	77·2	86·42	88·90	61·73	56·54	—
	Mean value of K	68·2	—	—	—	—	—
4th.	v	2053	2053	2053	2055	2055	2055
	K	73·6	67·90	65·43	123·45	123·45	65·33
	Mean value of K	68·4	—	—	—	—	—
5th.	v	2019	2020	—	—	—	2020
	K	75·00	80·17	—	—	—	83·18
	Mean value of K	68·4	—	—	—	—	—

In the above table our value of K has not been reduced to the standard density of the air.

17. Round 479, seventh screen, taking screen records to three places of decimals, then

$$t_0 = 0\cdot 416$$
$$t_{-1} = 0\cdot 344, \quad t_1 = 0\cdot 489,$$
$$t_{-2} = 0\cdot 273, \quad t_2 = 0\cdot 563,$$
$$t_{-3} = 0\cdot 203, \quad t_3 = 0\cdot 639,$$
$$t_{-4} = 0\cdot 134, \quad t_4 = 0\cdot 715.$$

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Then

$$Dt_1 = \cdot 145\,, \quad D^2t_1 = \cdot 001\,,$$
$$Dt_2 = \cdot 290\,, \quad D^2t_2 = \cdot 004\,,$$
$$Dt_3 = \cdot 436\,, \quad D^2t_3 = \cdot 010\,,$$
$$Dt_4 = \cdot 581\,, \quad D^2t_4 = \cdot 017\,.$$

Therefore, taking the records of 3, 5, 7, and 9 screens,

$$al = \cdot 0725\,; \text{ and}$$
(i) $$bl^2 = \cdot 0005\,,$$
(ii) $$bl^2 = \cdot 0005\,,$$
(iii) $$bl^2 = \cdot 0005055\,,$$
(iv) $$bl^2 = 0005118\,,$$

Taking $bl^2 = \cdot 000512$,

$$\log bl^2 = \bar{4}\cdot 70927$$
$$\log l^2 = 4\cdot 35218$$
$$\log b = \bar{8}\cdot 35709$$
$$\log 2 = \cdot 30103$$
$$\log (1000)^3 \frac{W}{d^2} = 9\cdot 14267$$
$$\log K = 1\cdot 80079$$
$$K = 63\cdot 21\,,$$

against Bashforth's 66·3 and mean value 67·8, when reduced to standard pressure and temperature of the air.

18. When three screens only are employed, then from the interpolation formula,

$$t = t_0 + as + bs^2\,,$$

so that the curve corresponding to the formula connecting t and s on a diagram is a parabola.

Then if M_1P_1, M_2P_2, M_3P_3 are three equidistant ordinates representing the screens, it follows from the geometrical properties of the parabola that the tangents at P_1 and P_3 intersect in a point T on M_2P_2, and that P_2 is the middle point of TV, where V is the point where the chord P_1P_3 cuts M_2P_2; also that the tangent at P_2 to the parabola is parallel to the chord P_1P_3.

This proves that the values of $\frac{dt}{ds}$ at P_1, P_2, P_3, are in arithmetical progression, and therefore the corresponding velocities are in harmonical progression; a theorem which is useful in determining the velocity at the first or last screen of a series.

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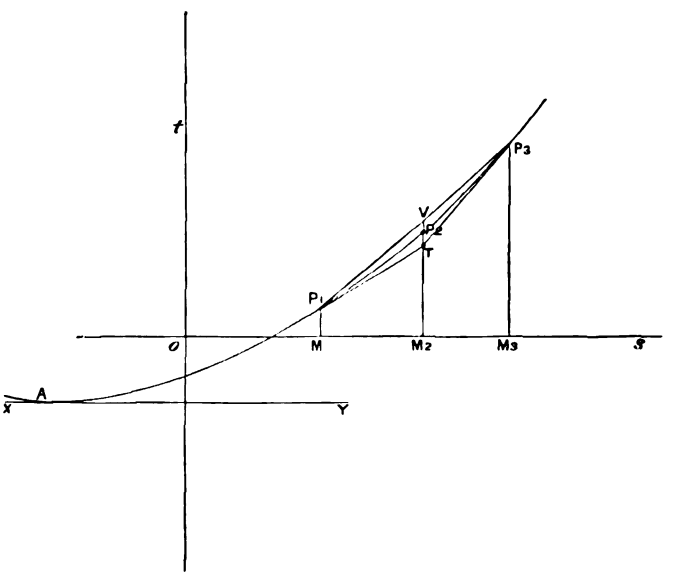
Also at P_2

$$\frac{dt}{ds} = \frac{t_3 - t_1}{2l},$$

or

$$l\frac{dt}{ds} = \tfrac{1}{2}(t_3 - t_1),$$

determining the velocity at P_2 by means of the screen records at P_1 and P_3.



Also

$$t_1 - 2t_2 + t_3 = 2VP_2 = VT = 2bl^2,$$

the geometrical interpretation of the quantity bl^2.

At the vertex A of the parabola $\frac{dt}{ds} = 0$, and the velocity is infinite, and then $s = -\frac{1}{2}\frac{a}{b}$.

19. When four screens are employed, the interpolation formula gives

$$t = t_0 + as + bs^2 + cs^3,$$

the equation of a cubic curve, having a point of inflexion where

$$\frac{d^2t}{ds^2} = 2b + bcs = 0,$$

or

$$s = -\tfrac{1}{3}\frac{b}{c}.$$

Generally, when an *odd* number of screens is employed, the corresponding curve connecting t and s is of *even* degree, and may therefore be free from points of inflexion; but when an *even* number of screens is employed, the curve connecting t and s is of *odd* degree, and has at least one point of inflexion, probably more; and if these points of

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inflexion occur on the curve between the points corresponding to the screens, then anomalous values of $\frac{dt}{ds}$ and $\frac{d^2t}{ds^2}$ are to be expected, as found in reducing the records of round 479, using an *even* number of screens, namely, twelve.

It is advisable, therefore, to use always an *odd* number of screens, and to calculate the values of al and bl^2 by considering at first the given screen as the middle one of (i) three (ii) five (iii) seven (iv) nine, &c., screens, and finally to take into account as many screens as possible, provided the number of them is odd.

Calculated in this manner the values of al and bl^2 will be found to be very slightly discordant, and a mean value of those found may be taken to be the true value.

20. It will be found also in general that the omission of the fourth decimal in the screen records will not materially alter the results of reduction; a matter of great importance when it considered that the chronographs have not yet been brought to the pitch of perfection of reading to four places of decimals of a second with accuracy.

For an account of the mechanical construction and the practical working of Chronographs, the reader is referred to Mr. Bashforth's "*Reports on Experiments, &c.*" 1870, 1879, 1880; to "*Report on Chronographs,*" by Captain W. H. Noble, R.A., and to "*Electro-Ballistic Chronographs,*" at the Vienna Exhibition, an article translated by Lieut. St. J. L. H. du Plat-Taylor, R.A., in these "Proceedings," April, 1886.

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AN ACCOUNT OF SOME OLD WROUGHT-IRON BUILT-UP GUNS TAKEN OVER IN FORT JHANSI, IN MARCH, 1886.

BY

MAJOR P. H. HAMMOND, R.A.

On the 10th of March, 1886, the fort and town of Jhansi were taken over by the British troops, in exchange for the fortress of Gwalior and cantonment of Morar, abandoned to Scindia.

The fort of Jhansi is an old Mahratta fort, on a rocky eminence, commanding the walled town of the same name. It is probably of considerable antiquity, and is well and strongly constructed.

On taking over the fort it was found to be in the usual state of ruin and neglect prevalent under native management.

Among the fallen buildings and the bushes that had overgrown them were found five guns. Two of these, a 12-pr. and an 18-pr., both iron, are of apparently European construction, and are not worthy of much remark, except for the fact that, the trunnions, having been at some time knocked off one of them, have been replaced by a trunnion ring, and trunnions of bronze strengthened with iron spikes driven into or cast in the metal.

The other three guns are more worthy of remark, being very early specimens of wrought-iron built-up guns. Two of them are of large size, having about 8¾ inches calibre, while the third is smaller, being about a 4½-pounder. One of the larger guns has been much damaged, large pieces of iron having been knocked and cut off it for the purpose of appropriating the valuable metal.

The other of the larger guns is pretty perfect, the outer coil at the muzzle having only been attacked, and, as they appear to have been in all respects similar, a description of one will serve for either. The metal of which these guns are constructed appears to be some kind of soft wrought-iron. Possibly there is some other metal mixed with it, as the guns show a remarkable freedom from rust. The inner tube or core of the guns consists of eleven segmental bars about 2½ inches deep, placed longitudinally so as to form a hollow cylinder of about 8¾ inches internal, and 13½ inches external diameter. These bars do

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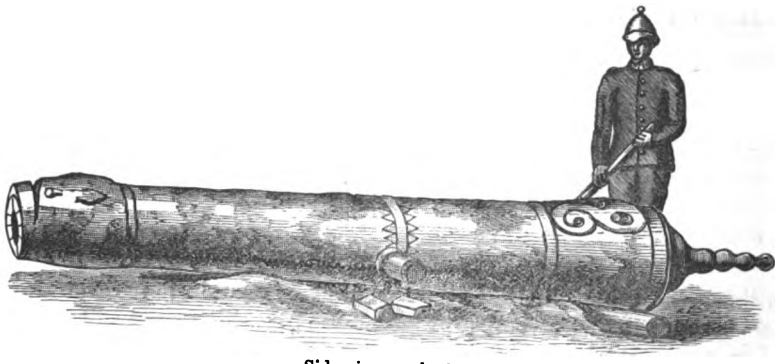
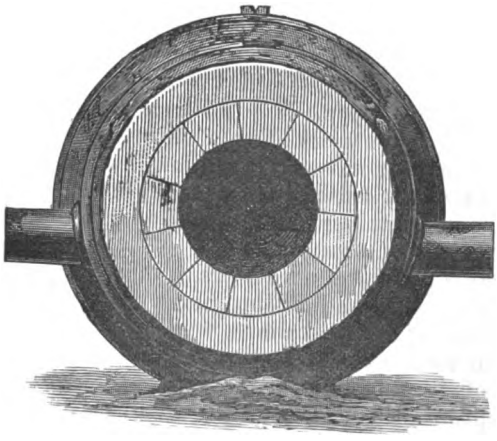
not appear to be welded together, but merely kept in their place by the surrounding parts of the gun. The outer jacket consists of two coils of wrought-iron bars about 2¼ inches square. These coils are so fitted and hammered together, that one would suppose them to be welded. However, in the second gun, where the coils have been hammered open, with a view to cutting off pieces of them for the sake of the iron, the manner in which they have opened along the coil appears to point to their being merely very accurately fitted and hammered together and not welded.



Side view, scale $\frac{1}{20}$.



Section, scale $\frac{1}{12}$.

The exterior of the guns is handsomely ornamented, the muzzle swell being formed into a lion's head, while the breech shows the elephant head of the Hindu God Gunesh.

On the complete gun is a plate bearing a Hindi inscription in raised silver letters, to the effect that, "This gun, named Bhowani, takes a "charge of 13 seers powder and 37 seers iron ball. It was made by "the holy Raja Oodut Singh, in the year 1781, Sambat (1724 A.D.)"

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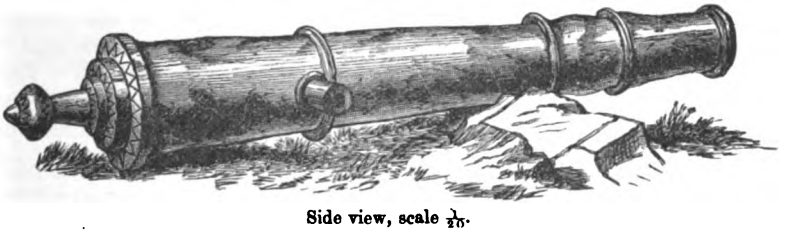
This charge, about 26 lbs. powder and 74 lbs. shot would be about right for a gun of this calibre, allowing for the weakness of powder of native manufacture. The principal dimensions of the gun are,—

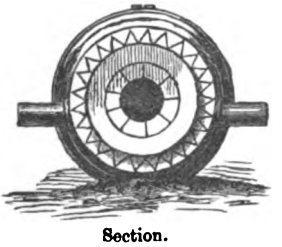
Length,—14 feet, without cascable.
Total length,—16 feet 10 inches.
Calibre,—8¾ inches.
Diameter, smallest part of chase,—2 feet.
,, at breech ring,—2 feet 4 inches.
Probable weight,—about 8 tons.

The smaller gun is of similar construction. Its dimensions are as follows:—

Length,—5 feet 9 inches.
Total length,—6 feet 6 inches.
Calibre,—3¾ inches.
Diameter at neck of chase,—7¼ inches.
,, breech ring,—11 inches.
Probable weight,—about 11 cwt.



Side view, scale $\frac{1}{10}$.



Section.

There are no signs of any carriages for any of the guns. A considerable quantity of shot, both of iron and stone, were found in the fort for both guns. It is difficult to see how the larger ones could ever have been mounted and fired. Much firing from such guns would probably bring down a good deal of the fort. Still, it is perhaps rash to assert what could not have been done by workmen who, with the tools more like children's toys than anything else at their command, produced 150 years ago such really magnificent pieces of ordnance.

JHANSI,
July 10th, 1886.

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MEMORANDUM

ON A

PORTABLE HELIOGRAPH,

DESIGNED BY

CAPTAIN R. H. MAHON, R.A.

THE heliograph, a drawing of which accompanies this memorandum, was designed in the commencement of 1884, and built in the Public Works' workshops at Madras. It had, however, several faults when finished; the instrument was too light, and liable to vibration when the legs were extended; several of the working parts were loosely fitted. The prohibitive charges of the shops, however, prevented these faults being remedied in a new instrument, and the heliograph was tested as it stood.

The Chief Instructor in Army Signalling, in forwarding the instrument for test to the O.C. 12th Lancers, remarked as follows :—

". . . . . *a.* The telescopic legs are an improvement on the usual pattern, as the same female screw serves for fixing the joint both when closed and extended.

". . . . . *b.* The sighting arm being attached to the tripod is a decided improvement.

". . . . . *c.* The cross-wires being attached to the sighting-arm, removes all chance of their being lost.

". . . . . *d.* The mirror being supported on two pillars enables a sight to be easily taken, as they do not obstruct the hole.

". . . . . *e.* The flashing key being fitted with a helical spring is much superior to the old arrangement of a flat steel spring.

". . . . . *f.* The mirror being attached to the head of the tripod reduces the time required to set up the instrument.

On the other hand I cannot help feeling that Lieut. Mahon, by having reduced his heliograph to less than 5 lbs. weight, has interfered with its efficiency as a signalling instrument. . . . . "

The Officer Commanding the 12th Royal Lancers, reported in October, 1884 :—

". . . . The general principle of the instrument appears to be very good; and if it was made more solidly, and some slight improve-

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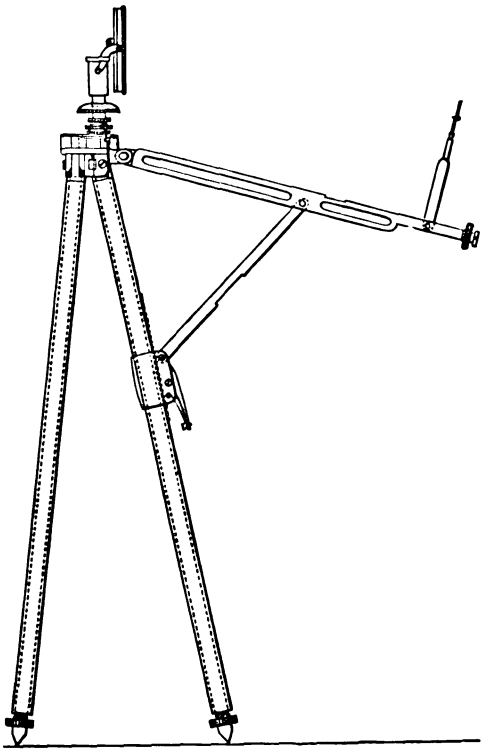
ments added to it, it would probably form a most useful addition to the signalling equipment of a cavalry regiment. It is at present so slight, that it might have its weight much increased without incurring any reproach on the score of want of portability."

To the above need only be added that the instrument is carried in a strong leather case, attached to the saddle or slung on the back. It is intended to be used, except under exceptional circumstances, with the legs closed, the operator sitting or kneeling. It can be set up and re-packed in a couple of minutes. It has an advantage not noticed in the foregoing. The flash is *adjusted* on a silver disc *below* the cross-wires, and therefore when *off* the object the great advantage of this is obvious.

The government of India sanctioned the cost of the instrument, and considered it an improvement on existing patterns, "but not sufficiently so to warrant its introduction."



COONOOR,
September, 1886.

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ACCOUNT OF THE BURMESE WAR OF 1885-86.

BY

COLONEL W. CAREY, R.A., COLONEL ON THE STAFF,

Commanding R.A., British Burma.

On the 24th October, 1885, instructions were received at Rangoon from the Government of India to make arrangements for the embarkation of a Siege Train of twelve 6·3-inch howitzers on barges. Eventually, and through my representation as O.C. R.A., British Burma Division, and a few days afterwards being appointed to command the R.A. of the Expeditionary Force, four 40-pr. R.M.L. guns were added. These guns and howitzers were to be on siege travelling carriages.

Four dredging barges belonging to the Port Trust Commissioners were first selected to place two howitzers or a gun and howitzer in each, but this would only account for eight out of the sixteen pieces. The remaining eight I proposed to embark in two coal barges of the Irrawaddy Flotilla Company, but this was opposed by the Chief Commissioner, who, with others, desired cargo boats. On my referring the question to Major-General Prendergast, V.C., in India, directions were issued for me to consult the Senior Naval Officer, (Captain Woodward of H.M.S. *Turquoise*) who acquiesced in my views and strongly supported me in every way, and to whom my sincere thanks are due for his able and valuable assistance.

So soon as it was settled that the mud barges were to be taken into use as part of the Artillery Fleet, they were handed over to the Bombay and Burma Trading Company, Limited, Mr. Jones, Manager, who received directions to convert them under my instructions. These barges were about five feet deep from deck to bottom of ribs, flat-bottomed, about 60 feet long by 16 feet beam over all. By plan it will be seen they consisted of a rectangular body forming a well in the centre of the boat about 48 feet by 13 feet, the rest of the boat was decked, bow and stern, with an 18-inch strip along the sides fore and aft. An iron strengthening beam divided the well into two equal divisions 24 feet by 13 feet. A water-tight compartment cut off the bow and stern from the centre of the barges, and those portions were used as cabins by the crew at ordinary times.

I decided to construct the gun deck in the well of these barges by laying cross beams over the ordinary flooring, a four-inch deck over that and four inches of laterite earth over all. Owing to the barges being flat-bottomed and of great beam there would be sufficient steadiness, the laterite earth would be firm and reduce recoil to a minimum, whilst check chains on each wheel would absorb all further recoil.

Although the barges were only taken in hand on the 26th October, by 6 a.m. on the 28th Mr. Jones brought a barge altered as above under the big sheers at Brookyn Street Wharf, when a detachment

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of 6/1 Southern Division under my directions embarked a 40-pr. R.M.L. gun in the bow and placed a 6·3-inch howitzer in the aft partition. The limbers were also lowered, one into each partition, and taken to pieces as lowered into the boat. The ammunition boxes were placed in the corner of each partition, clear of the gun, the gun-limber bodies under the muzzle of the howitzer, and the wheels of the 40-pr. were placed one on either side of the gun against the side of the barge, while those of the howitzer were placed against the stern and side. The poles went under the side decking. So arranged, with the guns in action, ample room was found for the two gun detachments in each partition. The guns on board, the steam tug took the barge in tow and moved out off Monkey Point, where it was intended to fire six rounds from each piece to test the working capabilities of the craft, and to see if guns of this size could be fought on travelling siege carriages, with 5-ft. wheels, in boats of this description. The following table gives the results of this practice, at which all officers of the battery, as well as Lieut.-Colonel Budgen and myself were present :—

40-PR. R.M.L. GUN.

Round.	Range.	Elevation.	Recoil.	Remarks.
No.	yards.	degs. mins.	ft. ins.	
1	4000	10 30	1 3	With check chains on the wheels.
2	4500	10 45	1 6	
3	3000	5 30	1 6	
4	2000	3 20	4 0	With check chains, and trail on a plank.
5	1000	1 52	7 0	No check chains, but trail on a plank.
6	1000	1 52	5 6	

6·3-INCH HOWITZER.

Round.	Range.	Elevation.	Charge.	Recoil.	Remarks.
No.	yards.	degs. mins.	lbs.	ft. ins.	
1	4000	35 0	4	0 8	With check chain.
2	4000	35 0	4	0 8	
3	3000	29 30	3	1 6	With check chains, trail on a plank.
4	2000	17 0	3	2 0	
5	1000	12 30	2	2 6	No check chains, trail on plank.
6	800	9 30	2	2 3	

The result of this practice was most satisfactory, it showed at once that with smooth water, as is usually found in rivers, both gun and howitzers could be fought as well on board as on shore. The recoil at the greatest, even for the gun, was not excessive, and with a sand-bag behind the wheels could be checked without check chains.

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Additional assistance to run them up after recoil required a tackle. For this purpose a chain was fastened to the hawser bight in the bow, to which the standing end of a tackle was hooked, the running or movable block being secured to the breast of the carriage; the gun by this means, after discharge and loading, was easily run forward. The decks were placed to allow of the gun-axle-trees being four inches below the bow deck. After practice the guns were landed and the following extra alterations were carried out, and four barges taken in hand for conversion :—

The stern compartment was converted into a powder magazine to hold 200 rounds, the bow deck hatchway was closed and secured, so that it could not be used for any purpose or blown open on discharge of the gun fired over it. Awnings over the well of the boat were arranged for; upright stanchions of angle-iron, 6 feet apart, were bolted outside, whilst X shaped supports were put up bow and stern, supporting a wooden ridge-pole fore and aft, this latter was afterwards found to be too cumbersome and heavy and was changed for wire rope. The awnings ensured that all rain water would fall clear of the barge. Iron shields about 2 feet high were put up round the well, front, and outside of the barge, those under the muzzle of the gun or howitzer could be shifted if required. As the free-board of these barges was very little, a 9-inch combing was fitted round the well of each barge.

The *Ananda* and *Ataran*, steamers of the Irrawaddy Flotilla Company, were at length allotted to these barges, the gun limbers were taken to pieces and lashed to the iron bulwarks of each steamer.

Having studied, on my late trip to Mandalay, the nature of the work required of the Artillery Siege Train to take or bombard five river forts and probably many land batteries, besides the siege of a walled city after landing, and having seen something of the intricacies of the river navigation, I determined that each gun-barge and steamer should be practically complete in itself so that in the event of the Field Park not joining, or getting separated, each boat might count on being equipped even to undertake the siege of Mandalay. A gunpowder magazine was therefore built in each steamer capable of carrying 150 rounds a gun. This, with 100 rounds a gun in each barge, gave 250 rounds a gun, one half of the government issue of 500 rounds per gun, and it was hoped no delay would arise by calling on the Field Park.

Arrangements had to be made for getting the guns and howitzers out of the barges with the least possible delay. The guns could be dropped in by means of sheers at a wharf and taken out again, but when it became necessary to land them, they must be lifted and run over the gunwale by hand on board their respective barges. The following arrangements were made and found to answer on three separate occasions :—

The gun or howitzer was run back amidships, muzzle pointing to the water, trail towards the bank on which it was to be landed, a 4-inch plank with lower end bevelled was placed from under each wheel to rest on a level with the top of the gunwale, a centre plank for the trail. These were supported on shell boxes. Two 6-inch landing ways, 20 to 30 feet long, with 2-inch border rims to prevent the wheels running

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over, stretched from the gunwale to the shore. A gun-tackle was hooked to a short chain and the movable block of the tackle was hooked to the gun wheel washers. The limber was brought up in parts and put together over the gunwale on the gun-ways, then run back and the gun limbered up. The detachments in the boat hauled on the gun tackles, and the gun was run up over the side, the gun was then run up the bank with drag ropes. I superintended this operation at Rangoon, Prome, and Mandalay; ten minutes would land a gun after the barge was secured. The four barges were complete and ready by the 7th November, when Major-General Prendergast and his Staff arrived.

With regard to the remainder of the Siege Train, it was determined to embark the stores, &c., on board a coal barge of the Irrawaddy Flotilla Company. The barge was about 204 feet long by 35 feet wide, the bow and stern were decked for 28½ feet, and a strip of side decking 2 feet 6 inches wide on both sides gave fore and aft communication, the rest of the barge was open about 144 feet long by 26 feet wide, this was subdivided into compartments. First a bulk-head, rising about 15 inches above the deck level, ran fore and aft amid-ships, besides which it was subdivided by transverse bulkheads into six water-tight compartments on each side, measuring 24 feet long by 13 feet wide, with the exception of the compartment next the bow, each was again divided by a transverse iron beam or strengthening girder, which really divided the whole space into rectangles 12 feet long by 13 feet wide, with a rise to the centre amidships of about 15 inches. On this I determined to place the two 40-pr. R.M.L. guns, one in each bow compartment, with their axles four inches below the iron bow deck. For this a gun deck had to be constructed in the barge 2 feet 10 inches below the bow deck. Taking care to abut the beams against the iron ribbing of the barge, a deck was constructed on beams and struts and overlaid with four inches of laterite earth.

For the six howitzers, the alternate half of the four centre compartments and the whole of the stern compartments were decked over, taking the slope of the angle iron ribbing or girders as direction of the deck level. The plans and sections will give the general idea of how the deck was supported and stayed. The decks consisted of two three-inch planks, with four inches of laterite earth overlaid, every alternate interval being left open for gun stores, with free admission to the hold or body of the barge. In rear of the 40-prs. and under the first howitzer deck, two gunpowder magazines were constructed, one on either side of the longitudinal bulk-head. Two more were built amidships, and two more in the space under the fourth howitzer, making six magazines in all.

Strong ladders led from each howitzer deck to the bottom of the barge, and each magazine had a lobby in front of the magazine door. Iron shielding fore and aft was erected for protection of the gunners in action. The plates were about 3 feet high and could be taken down in the event of its being necessary to do so. Holes were cut in the bottom deck planking for baling out, no pumps being available for this vessel.

An awning was arranged to cover each gun deck; unfortunately

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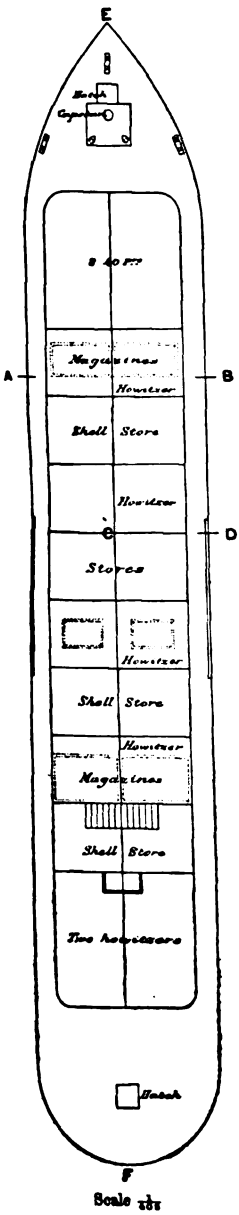
these awnings did not extend over the full beam of the barge, large quantities of water therefore fell on the gun decks and on the open spaces between the decks. With four days heavy rain the water leaked into the magazines and two or three barrels of gunpowder got damaged.

Besides the iron shielding, three iron traverses were run across the ship, one in rear of the 40-pr. guns, one amidships, and one in front of the two rear howitzers.

THE WHITE SWAN.



This about completed the actual alterations of the barge which was now christened the *White Swan*,—the Carey crest. Having had some difficulty in getting her equipped, I determined to show I was not afraid of my share of the responsibility and so gave her that name. Sailors and others nicknamed my flotilla "Mother Carey and her chickens," the latter being the four mud barges. The *White Swan* was taken in hand by the Irrawaddy Flotilla Company, at Dalla Dockyard, and was completed by the 12th November, when she received her armament.

She was inspected by Major-General Prendergast on the 8th November when he recommended certain alterations to be carried out, as to strengthening her decks and the addition of iron shield traverses as before described. Both firms, the Irrawaddy Flotilla Company, and the Bombay and Burma Trading Company, deserve the greatest credit for the rapid and substantial way in which they fitted out the barges entrusted to them. Like the smaller barges, I determined this barge should be independent and carry 250 rounds per piece of ordnance as well as sufficient landing gear.

While this was going on, instructions had arrived that the Siege Train would consist of—

12–6·3-inch howitzers,
4–40-pr. R.M.L. guns,
12–5½-inch royal mortars,

to be manned by three batteries of Artillery two Garrison and one Field, (dismounted). These therefore had to be distributed to work the Siege Train, and it was arranged that three tug steamers would suffice.

The *Ataran* and *Ananda* were told off to two barges each. The *Yunan* was to tow the *White Swan*. Two of the small barges were each armed with a 40-pr. gun in the bow and a 6·3-inch howitzer abeam and given to the *Ananda*. The two others with two 6·3-inch

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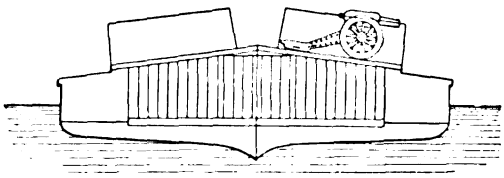
howitzers in each were given to the *Ataran*. While the *White Swan* took two 40-prs. in her bow, six 6·3-inch howitzers on the broadside and twelve 5½-inch mortars.



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250 rounds per gun or howitzer, and 2000 rounds for the mortars, was the quantity of ammunition embarked. The remainder of the 500 rounds per piece was left in charge of the Field Park.

In the meantime 6/1 Southern Division, with the assistance of the Commissary of Ordnance, were preparing a pair of sheers, two gyns, parbuckling skids with capstans, and other gear that might be necessary for landing and moving guns across a country cut up with deep choungs or muddy creeks; moreover the Ordnance Department, India, might not forward such stores with the Siege Train. Fortunately I had lately visited the forts of Saygone, Ava Redoubt, Sagaing and Thabyadan, not only walking round but over them. Other information up to date had been obtained from native sources only, even Major MacNeil had not succeeded in gaining admittance to them. I also succeeded in reconnoitring the road from Patanago to Khooleygone fort which enabled the General to turn and surprise that fort on the 17th November.[1] With my acquaintance of the ground and knowing the strength of our expedition I came to the conclusion that every gun should be mounted and able to fight on board ship, and that they should be ready for landing at a moment's notice. With regard to the European Mule Battery, the *Panthay* steamer and two flats were taken up on the 5th November and the following alterations recommended and ordered:—

a. Side decking on both sides of each flat to be laid level with the top of each hatchway, falling a couple of inches to the sides; gangways to be kept clear.

b. Deck for fifteen mules between the centre and fore hatchway amidships, and between the centre and aft hatchway was afterwards added.

c. Bamboo rails, fore and aft, in line with the sides of the hatches.

d. Lower planks on either side of the flats to be knocked out for ventilation and cleanliness.

e. Water tanks, 400 gallons each, six to each flat and two to the *Panthay* steamer.

f. Latrines as per scale.

[1] See Report by Colonel Carey on his visit to Mandalay, dated the 16th October, 1885, as published by the Qr.-Mr.-General's Department in India.

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g. Native followers to live on the hatchways and open spaces on the deck flats.

h. Harness to be stowed below between sides of flats and sides of hatchways.

These alterations were all prepared and executed by the 10th November, when 9/1 Cinque Ports Division arrived. It was also arranged that the *Ashley Eden* should convey No. 4, Punjaub (Hazara) Mountain Battery, and be so arranged as to have two guns in the bow, and two in the outer bow of each flat. These guns being only 200 lb. guns, no alteration in the decks were considered necessary. In like manner No. 1 Bombay Mountain Battery was to be embarked in another steamer with two flats, and the guns were to have been similarly arranged. Unfortunately, by the delay in taking up steamers, none were available on the date of arrival of the battery, consequently the battery was transferred to No. 38 flat and attached as a third flat to the *Shoaymyo* steamer.

These two native batteries, without mules, and without coolies for transport, were transferred from their sea-going steamer to the river flats and boats off the Hastings shoal, and consequently I was unable to inspect them until they joined the force above Thayetmyo.

With regard to these batteries, it had been decided in India that coolie transport was likely to be the most efficacious and that mules would not answer; why, I did not know, but the coolies had not arrived up to date. Another question was being mooted at this time, viz., to turn the Elephant Mountain Battery at Tounghoo into a coolie battery, fortunately the idea was given up.

I can hardly say that the coolie proposal started well. There were two batteries and no coolies, some 700 were required to equip each one; so long as the batteries remained on board ship it is true the coolies were not required, but it might be necessary to land them at any date after arriving at Minhla.

It has been stated that I proposed that the 25-pr. R.M.L. guns to be handed over to the Navy should be placed on board steamers and flats ready for action in the same way as arranged for all other guns. It may appear curious that I should have this done irrespective of the Navy who were to man them, but it is to be remembered that I alone had inspected the Ava forts, had lately come down, and having studied the probable course of the force, knew that most probably every fort would have to be demolished by Artillery before landing a gun of any size. As the course of the river was intricate and the stream rapid, no leading vessel dare anchor, but must proceed slowly on, as the artillery barges alone would have a broadside fire, and these latter only should anchor abreast of a fort. Troops might then be brought up as close as possible for landing, but a leading vessel anchoring would throw all other artillery vessels out of action, and force a landing of troops on the General that might be inconvenient and inopportune.

The Naval Brigade consisted of the *Irrawaddy*, with two 20-pr. R.B.L. guns and machine guns, several steam launches with a bow gun. The *Ngawoon* survey vessel and the *Pulu*, both with a cargo

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boat carrying a 64-pr. R.M.L. gun in the bow. These were splendid vessels fitted with naval slides and carriages, and the sailors were at home with them, but when it came to 25-pr. R.M.L. guns, it was proposed to carry them as cargo and land them when required. "No five-foot wheeled carriages for us on board-ship!" Well, natural enough; however the gunner had arranged to fight 40-prs. and 6·3-inch howitzers, 7-prs. R.M.L. of 400 and 200 lbs. weight, all on wheeled carriages and saw no reason why he should not have the assistance of the 25-pr. R.M.L. guns. I therefore got permission and prepared two steamers, the *Shoaymyo* and *Burma* with their two flats, and strengthened the decks with supports and put down laterite emplacement, &c., &c., and arranged for embarking them like the 40-pr. R.M.L. guns, but the Navy declined, they did not approve, and sent up four guns that had arrived as cargo. It was not to be expected that they would acquiesce in a landsman's way of adapting a field carriage to water service. The Navy undertook to land and fight them when required. It was a pity to see such fine guns carried as cargo, and therefore useless up to a certain point; but the Navy ought to be the best judges as to whether they could fight the guns or not.

The other eight guns were brought up by the Naval Brigade from the flagship, H.M.S. *Bachante*. Admiral Sir Frederick Richards, K.C.B. arrived on the 27th in time for the surrender of Ava, and a Naval Officer succeeded in placing three if not four of these in action, the wheels rested on short inclined planes secured with a breeching. My objection to the plan was the play and recoil allowed, and the certain jump of the gun on being stopped in recoil when brought up by the breeching. What would happen with the jump and rebound is difficult to say, but this was the difficulty that I had worked against successfully. There was no opportunity to test the arrangement.

The embarkation of the Artillery had now been carried out. The Major-General arrived on the 7th November, inspected the fleet on the 8th and found 6/1 Southern Division busily engaged in embarking two 40-pr. R.M.L. guns in two barges with 100 rounds a gun. In the course of the day the *Tenasserim* arrived from Madras with 4/1 North Irish Division and Q/1, R.A. Eighty men of the former battery, under Major Broadfoot, were transferred to the *Ananda* steamer, the remainder of that battery, under Lieut. Kaye, with Q/1, R.A., were transferred to the *Yunan*. 4/1, N.I. then took charge of their two barges which 6/1 Southern Division handed over.

On the 9th all hands were employed in completing the loading of these barges. Unfortunately the Indian arrangements had divided the Siege Train, giving a portion to each battery and 100 rounds per piece of ordnance. Thus 4/1 N.I. had six howitzers, Q/1, was supposed to be in charge of twelve 5½-inch royal mortars. On arrival, 4/1 N.I. received over two barges with a 40-pr. R.M.L. gun in each bow and required only two howitzers with 500 rounds of ammunition. Here again they had four howitzers surplus and plenty of ammunition for the two howitzers, but, what with bad weather, and embarking in an open roadstead, boats went wrong and part of the ammunition was

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put on other vessels. The ammunition was short in every particular. The *Ananda* had therefore to await the arrival of the Field Park Reserve.

3/1 Scottish Division under Major Baker arrived on the 10th and got alongside a wharf higher up the river; on the 11th her two barges moved up, and four out of her six howitzers, with the whole of the 600 rounds or 150 rounds per piece were embarked. The order was 250 rounds, but the captain of the *Ataran* (on board of which Major Baker and eighty men embarked, the remainder being transferred to the *Yunan*) declined to take any more; I then referred to the Manager of the Irrawaddy Flotilla Company, who, although he acknowledged the steamer ought to be able to take it equally as well as the *Ananda*, gave his decision that captains of vessels must have a certain amount of discretion, and declined to act. On this there was no reason for delaying the vessel and she sailed on the 11th, short of fuzes like the rest. However, I always had the feeling that had the extra 400 rounds ordered been on the spot instead of at sea, they would have been shipped, and I have not been able to get over that feeling; at all events I now had to provide extra accommodation for 400 rounds of ammunition, and trusted to the *White Swan* to carry it.

9/1 Cinque Ports Division, under Capt. Smyth, arrived on the 10th, landed their mules, embarked and steamed away on the 11th in the *Panthay*. On the 12th one of the steamers with ordnance stores came alongside the wharf, the *Ananda* came alongside of her and filled up with powder, &c.; all tubes, &c., deficient being as far as possible supplied from Rangoon Arsenal and afterwards made good by the Field Park, and she sailed in the afternoon. On visiting this steamer I found the work of discharging cargo excessively slow; besides this, the cargo was mixed, a barrel of cartridges here, and a shell there, gunpowder barrels were being rolled about the deck indiscriminately with live shell and other stores; speaking to the captain he improved matters to a certain extent, but the risk was unavoidable. The sooner it was got through the better it would be, and as all cartridges were supposed to be sound, it was hoped no loose powder would be found. Providence is kind to the British nation, for never was a rasher act done than in sending the vessel to sea in that state.

The ordnance stores from this vessel, the *Bandora* or *Mir Jehan*, were landed on the wharf and sorted, so that on the 13th, when the *White Swan* came alongside to take in her armament, one of the quickest feats in arming a vessel took place. Between 7 a.m. and 1 p.m. this vessel embarked, with the help of big sheers, two 40-pr. R.M.L. guns and six 6·3-inch howitzers, all on travelling siege carriages with limbers, 250 rounds per gun were also taken on board with 400 more, left behind by the *Ataran*, twelve 5½-inch mortars with 2000 rounds of ammunition, a pair of sheers, capstans, and other artillery stores. She cleared from the wharf at 1 p.m. and sailed at 4 p.m. Care was taken to keep a 3-foot way round the sides of the barge to allow of room for a man to plug shot holes.

On the 30th October Lieut.-Colonel Budgen was appointed second in command, and was directed to take charge of the Siege Train

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with Capt. Anderson, 6/1 Southern Division, as his adjutant in the *White Swan*. Captain Saunders, Adjutant to the Artillery, Burma Frontier Force, arrived on the 8th November, this officer and myself, having seen all the Artillery sail, waited for the fuzes and proceeded by rail to Prome.

The *Ashley Eden* with No. 4 Punjaub, (the Hazara) Mountain Battery, and the *Shoaymyo*, with No. 1 Bombay Mountain Battery, sailed on the 13th. The *Ashley Eden* took four trench carts, two for each of those batteries. These batteries were shipped below the Hastings shoal, and I did not inspect them until after the whole force had united above Minhla.

On the 10th November, Major-General Prendergast issued the following Burma Frontier Force Order:—

"Every steamer, barge, lump, or other craft, fitted for R.A. guns, should be inspected by the senior officers R.A. and R.E., and a certificate given that the fittings are good, strong, capable of bearing all shocks, strains and stresses that can be brought to bear against them without being injured or injuring the boats."

In accordance with this order, the various steamers and barges were re-inspected and the certificate signed by Capt. Wilkieson, R.E., and myself, and were duly rendered for each artillery barge, flat, and steamer.

The following note was added to the order:—

"The R.A. officer is responsible that the guns are so placed that they can be worked fairly, and that the magazines are secure and sufficient."

A certificate of buoyancy for the barges was also called for and given by the senior naval officer present.

Owing to the change in the distribution of the Siege Train from that arranged in India, and being more in accordance with regulation, that the officer commanding the Siege Train should be responsible for the Siege Train accounts, the following R.A. R.O., Burma Frontier Force, was issued dated the 9th November:—

"Officers commanding batteries will hand over receipt and delivery vouchers for ordnance and gun stores to Lieut.-Colonel Budgen, R.A., commanding the Siege Train, who alone is responsible for them."

Besides this the following orders and instructions were issued on the 9th and 10th November:—

Siege Train.

12–6·3-inch howitzers ... ... } On travelling carriages.
4–40-pr. R.M.L. guns ... ... }
12–5½-inch royal mortars ... ...

LIEUT.-COLONEL BUDGEN, R.A., *in Command.*
CAPT. ANDERSON, 6/1, S.D., R.A., *Adjutant.*

Distribution.

a { 6–6·3-inch howitzers } R.M.L. } On the *White Swan.*
{ 4–40-pr. guns ... }
{ 12–5½-inch mortars ... ...

Q/1, R.A., +⅓rd of 4/1, N.I.D., R.A., +⅓rd of 3/1 S.D., R.A.

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b { 2–6·3-inch howitzers } R.M.L. on mud barges.
c { 2–6·3-inch howitzers }

3/1 S.D., R.A., ⅔rds only.

d { 1–6·3-inch howitzer / 1–40-pr. gun } R.M.L. on a mud barge.

e { 1–6·3-inch howitzer / 1–40-pr. gun } R.M.L. on a mud barge.

4/1 N.I.D., R.A., ⅔rds only.

b and *c* will be taken in tow by the steam-ship *Ataran*, on which ⅔rds of the 3/1 S.D., R.A., will embark—1 major, (Baker), 1 captain, 2 lieutenants, and 80 N.-C.-O.'s and men, and take over the armament of four 6·3-inch howitzers with 250 rounds per howitzer; 100 rounds per howitzer, including all the case shot, will be embarked on board the barges with a proportion of ammunition aft in the magazine. 150 rounds per howitzer of made up cartridges will be stowed in the magazine, aft hold of the S.S. *Ataran* which will take the two barges in tow. A gyn, 14-ft. skids and tackle for mounting and dismounting guns to be stowed on board the steamer.

The following stores were on board each barge :—

6–7 ft. 3 in. planks, bound with iron, for each howitzer.

3–4-in. planks, for inclined plain, for running the howitzers out.

3 planks for landing stage.

Iron chain in bow for hooking gun or luff-tackle to.

2 anchors and cable for moving barge as required.

Awning.

The howitzers were put on board complete, one in the bow forward, one aft of the centre beam, half right or left according as to whether the barge was on the port or starboard side of the steamer.

The ammunition limber boxes were to be taken off the carriages and placed in rear of the howitzer's furthest flank of each piece, fuze box between the two, and were to open to the proper front.

Skidding 9 inches × 6 inches, 4 inches × 4 inches, &c., were put on board in case of emergency. Two gun or luff tackles with each piece, and one spare on board the steamer. Two gunpowder cloths were supplied for use in each magazine in barge and steamer. One iron sling chain to each *Ataran* and *Ananda* steamer. No powder barrel was allowed to be opened in the magazine, but on a cloth outside on deck.

When the ammunition in one limber box had been used it was to be replenished at once from the magazine.

A set of cooper's tools for opening powder barrels was issued for each magazine, and two spare sets placed on board the *White Swan*.

No person was allowed in the magazine with boots or shoes on, and a powder cloth was laid on the floor of the magazine, between the doorway and barrels inside, when any work was going on. When the magazines were closed these cloths were well shaken to get rid of all grit that might be on them, and then put away in the magazine until required. No smoking or lighting of pipes or fires was allowed on any of these barges.

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The remainder of 3/1, S.D., R.A., embarked on the S. S. *Yunan*, in charge of the *White Swan* and was attached to Q/1, R.A., for rations only.

A check chain long enough to lock both howitzer wheels after passing through the trail plate eye, and a second locking chain to the 40-pr. guns was supplied for securing the wheel before firing, also pads to go across the felloe in the angle of the felloe and spoke. Screw-drivers, 1 per gun or howitzer, were taken for opening shell boxes.

Extract of all orders were furnished to the Officers Commanding 3/1, S.D., R.A., 4/1, N.I.D., R.A., Q/1, R.A., and to Lieut.-Colonel Budgen, Commanding the Siege Train.

The following were also issued :—

1. Officers Commanding vessels of Siege Train will detail a guard daily of a sentry armed with a carbine, who is to be mounted at all times in each of the barges, except when drill is going on. The sentry is to have particular orders that no smoking, fire, or lights of any kind are to be allowed on the barge.

2. The whole of the stores are to be arranged in the barges and steamers as soon as possible, and in such a way that they can be found when wanted. Twenty shell are to be unpacked at once, and kept ready for immediate use, the boxes of thirty more are to be unscrewed.

3. Officers Commanding batteries are reminded that though the barges are sufficiently high out of water as to be practically buoyant and safe, yet at certain points of the river when a breeze is blowing, a certain amount of sea will get up. This may wash the top of the barge, but so long as the water does not wash over the top of the gunwale in any quantity no inconvenience will occur, but otherwise the laterite will become wet and clayey, and every precaution against this occuring is to be taken. The best plan will be to request the Captain to slacken speed and not drive against it, and if necessary to lighten the barges. This can be done by removing the 100 rounds of shell of the bow-gun on to the deck of the steamer, and running the gun or howitzer 6 or 10 feet to the rear.

4. Officers Commanding batteries will exercise their men daily, morning and evening, in gun drill, with and without check chains, in using which care is to be taken that no slack is allowed, and the wheel is to be turned until all the slack is taken in.

5. When in action the wire rope for awning over the second howitzer is to be unhooked and fastened clear of the line of fire, the intermediate stanchions are to be inclined down and to the rear.

6. If light admits of it, practice in landing howitzers and guns is to be carried on daily. A gyn is placed on each steamer, and it is expected this will enable a gun to be pulled out of any difficulty.

7. The barges are to be pumped out morning and evening, and due notice taken of the amount of water. This was afterwards altered to "N.-C.-Officers in charge of the guard will try the pumps on barges

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every fourth hour, and should there be any accumulation of water, the barge will be pumped clear by a party to be detailed for the duty; a record of the leakage, measured by time occupied in pumping out, is to be kept."

To the Officer Commanding 9/1, Cinque Ports, R.A. :—

The battery will embark in the Irrawaddy Flotilla Company's Steamer *Panthay*, attached to which are two flats for mules. Two guns will be mounted in the bow of the *Panthay*, one on either side, and two on the outer bow of the flats alongside.

The Officer Commanding will keep the guns ready for action at any moment, with one or two boxes of ammunition alongside every gun.

The gun emplacements of laterite have been prepared to check the recoil, and it is anticipated from practice carried on with the 6·3-inch howitzers and 40-pr. R.M.L. guns on barges and on laterite flooring, no trouble will arise in checking recoil. Arrangements are to be made that the battery may be landed at the shortest notice. Every gun store is to be stowed away by sub-divisions, and everyone taught his place, and practised daily. The saddlery and harness are to be disposed of by sub-divisions, that every driver may be able to put his hand on it at once. If room admits of it, the mules should be saddled daily to accustom the men to do so quickly on board ship. It will be found easier to hand out the ammunition boxes and guns and load them on the mules after landing, but every endeavour should be made to learn to saddle on board and to move the mules out saddled, as when required the ground will be very limited and will be required for other troops as well. Care is to be taken that half the battery are stowed on the flat right side of the *Panthay* and the other half battery in the flat on the other side. Gun mules on the outside of each flat, No. 1 gun mule being alongside a gangway, so that a sub-division can file out of each gangway (there are three) in order. Orders were also given to No. 4 Punjaub (Hazara) Mountain Battery and No. 1 Bombay Mountain Battery, but as their mules were left in India to be replaced by coolie carriage, the orders only applied to the ship they were to embark in and to the guns being kept ready for action in the bows.

On embarkation, two trench carts were issued to each Native Mountain Battery and Siege Train Battery and two extra for the *White Swan*. In this way every officer received clear and explicit instructions with regard to his charge and duties. Major-General Prendergast and portion of Staff left Rangoon for the front, *via* Prome, by mail train, on the 13th November.

On the 14th November the *Irrawaddy* steamer with launch, *Kathleen*, attacked a stockade or entrenchment which they destroyed, and captured a King's war vessel.

On the 15th, taking the fuzes for the several batteries, I and my adjutant left by the 9.30 p.m. train for Prome. Captain Woodward, R.N., senior naval officer of the station, as well as other staff officers went also. On arrival at Prome on the 16th, the party embarked on the *Ataran*. At Thayetmyo we transferred ourselves to the *Ngawoon*

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surveying vessel, which was to start immediately. It did not however leave till daylight. This vessel occupied the coaling station, and the *Ataran* had to wait to coal as also the *Yunan* which arrived later on the night of the 15th and which overhauled the *Ngawoon* about 1 p.m. The *Panthay* with 9/1, C.P.D., R.A., was ahead.

Whilst at Prome I had an opportunity of seeing a howitzer run out over the gunwale of the barge and run back into its place, explaining to Major Baker how the operation was to be performed.

On the 16th Major-General Prendergast with the advance, including the *Irrawaddy*, Capt. Clutterbuck, R.N., the steam launch *Kathleen*, the *Panthay* with 9/1, C.P.D., R.A., &c., attacked the entrenchment at Nyoung-bir-maw, landed the battery below the work, which after a short march took it in flank, and after firing a few rounds forced the enemy to evacuate the position, the guns of which were at once disabled.

At noon on the 17th from the *Ngawoon* dense columns of smoke were seen rising from the direction of Minhla, and at 6 p.m. the *Ngawoon* joined the force already in possession of Minhla and Khooleygone fort.

The town of Minhla below the fort had been fired by the bursting of a shell from the *Irrawaddy* steamer and was burnt down. It appears that the Major-General Commanding had determined to attack at once without waiting for the Siege Train.

Landing a brigade of troops with 9/1, C.P.D., R.A., at Patanago, he marched by the ridge, turned and surprised the fort, which he also commanded from the land side. At the same time he landed a brigade of Indian troops below Minhla, and directed them to march on the fort. This brigade had no Artillery. The *Irrawaddy* steamer with launch *Kathleen* were to attract attention of the enemy to the river by artillery fire on the forts. The Minhla brigade advanced and met with considerable resistance, owing to concealed batteries, and eventually stormed the fort by the north and south ramps, which led to the centre on the top of the west face of the fort. Some 5 officers and 26 N.-C.-Officers and men were killed or wounded. Amongst the wounded was D.-A.-Q.-M.-General Major MacNeil who edited the *Gazetteer of Burma*, 1883.

Lieut.-Colonel and Bt.-Colonel Auchinlech, R.A., who had been appointed to command the R.A., British Burma Division, *vice* myself, found himself in the action of Khooleygone fort, and was at this time appointed to command the line of communications.

The enemy lost at Minhla 170 killed, 40 wounded and 270 prisoners, who were captured in Minhla fort, for once the troops got up to it there was no escape.

The surprise at Khooleygone fort, garrisoned by 1,700 men, was so complete that Moung-Souhla-Sing, the Bo or Commander and a Woon of the place nearly rode into the English Brigade before he knew an enemy was at hand, and only escaped by riding down the precipitous side of the ridge northwards, by which also the garrison escaped.

There being no room on the *Thanbyadine*, head-quarter vessel, I and my adjutant proceeded on board the *Yunan*. On the 18th, on reporting myself to the General I received orders to disarm Minhla fort and embark the guns on a flat or steamer, but no Artillery were to be landed

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for the purpose; also that a division of No. 1 Bombay Mountain Battery was to be landed as part of the garrison, which consisted of 2 companies of the 2nd Bengal Infantry and 1 company of the Liverpool Regiment, whilst 1 company of the Liverpool Regiment, 2 companies of the 2nd Bengal Infantry, and 1 company of Sappers and Miners occupied Khooleygone fort with orders to destroy it. Sending the adjutant to No. 1 Bombay Mountain Battery with orders to land a division of 2 guns I proceeded to Minhla, and, with the assistance of the Bengal Infantry, ran all the guns down out of the fort to the river bank, where, with the assistance of the Madras Pioneers, I got well on embarking them, when permission was given to land some gunners to complete the work. Khooleygone fort was disarmed by the R.E. who afterwards blew it up.

The idea of continuing the advance of the 18th failed, but the surveying vessel *Ngawoon*, Capt. Carpenter, escorted by the *Irrawaddy*, Capt. Clutterbuck, to which was added the *Ataran*, Major Baker, were sent on to reconnoitre. On the morning of the 19th the *Ananda* arrived and reporting she found two barges too much, with the sanction of Capt. Watson of the *Yunan*, I took one barge and secured her to the steamer. Shortly after signal was made for the whole force to get under way.

The Artillery force now up was as detailed below :—

DETAIL, ROYAL ARTILLERY, BURMA EXPEDITIONARY FORCE.

Steamer.	No. of barges.	Armament. 40-pr.	Armament. 6·3″H.	5½-inch mortar.	Battery.	Commanding Officer.	Remarks.
Ananda.....	2	2	2	—	⅔ of 4/1 N.I.	Major Broadfoot.	Siege train, with 250 rounds per piece and landing stores.
Ataran	2	—	4	—	⅔ of 3/1 N.I.	" Baker.	
Yunana.....	White Swan.	2	6	12	Q/1 R.A. ⅓ of 4/1 N.I. ⅓ of Sc. D.	Lt.-Col. Budgen Major Hewitt.	
Total ...	5	4	12	12	3 Batteries.	—	—
Panthay ...	2 flats.	6 screw guns, with mules complete, 9/1 Cinque Ports, Capt. Smyth.					
Ashley Eden	2 flats.	6–200-pr. guns, with 100 coolies, 4 Punjaub, Hazara, Capt. Wace.					
Shouay-myo	1 flat.	9 " " "				1 Bombay M. Battery, Capt. Hewson.	

Besides the above the *Burma* and *Shoaymyo* were fitted out for the Naval Brigade, 8–25-pr. R.M.L. gun emplacements, ready to mount 2 guns in the bow and 1 in each flat. The Naval Brigade received 12 guns. The whole of the foregoing were fitted out by the Officer Commanding, Royal Artillery, Burma Division, and Burma Field Force.

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The force sailed as per order :—

BURMA FIELD FORCE RIVER FLEET.

Order of sailing in Squadrons.	Distinguishing Number.	Remarks.	Corps.	
1	—	Indian Marine Steamer Irrawaddy.	Naval Brigade.	
—	1	Thanbyadine	G. O. C. and Head Quarters Staff.	
2	15	Pulu	Naval Brigade.	
		Flat No. 24	—	
3	14	Palow	Naval Brigade.	
		Flat No. 6	Q/1, R.A.	
4	12	Yunan	½ of 3/1 Scottish } Division.	
		White Swan	½ of 5/1 N. Irish }	
5	13	Panthay	—	
		Flats 28 and 30	9/1 Cinque Ports, R.A.	
6	6	Shoay-myo	Q. O. Sappers and Miners.	2nd Brigade.
		Flats 26, 27 and 28	No. 1 Bombay Mountain Battery.	
7	2	Burma	Head Quarters, 2nd Brigade.	
		Flats 17 and 42	Hampshire Regiment.	
8	5	Shintsawboo	1st Mounted Pioneers.	
		Flats 56 and 57	12th Mounted Infantry.	
9	9	Ashley Eden	23rd Mounted Infantry.	
		Flats 34 and 43	4th Punjaub Hazara Battery.	
		Lighter 38	Telegraph Stores.	
10	17	Paulang	Travelling Hospital.	
11	10	Ananda	¾ of 4/1 N. Irish Division.	
12	3	Yankeentown	Liverpool Regiment.	1st Brigade.
		Flats 19 and 25	Telegraph Department.	
13	7	Irrawaddy	21st Mounted Infantry.	
			25th Mounted Infantry.	
		Flats 40 and 49	Head Quarters, 1st Brigade.	
14	18	Waikema	Travelling Hospital.	
15	11	Ataran	—	
		2 barges, 4 guns	¾ of 3/1 Scottish Division, R.A.	
16	4	Aloung Pyah	Royal Welsh Fusiliers.	3rd Brigade.
		Flats 21 and 45		
17	8	Shooreah	2nd Bengal Infantry.	
		Flats 18 and 50	11th " "	
18	20	Salifoo	—	
		Flats	Mounted Infantry.	
19	16	Rangoon	—	
		Flats 41 and 44	Floating Hospital.	
20	21	Mendoon	Reserve Steamer.	
		Flats	Coolies coal.	
—	19	Kah-byoo	Commissariat and Postal Service.	
—	1	Doowoon	Took place of Thanbyadine, 21st Nov.	

The foregoing order was generally kept.

About noon on the 19th the *Ataran* returned without her barges and Major Baker reported to O.C. R.A. that, the previous afternoon, not being able to make headway against the current about eight miles above Minhla, and hearing the *Irrawaddy's* guns in action, he anchored a barge, leaving a mate and lascars in charge. It was then too late to get back and bring up the barge, to which he returned in the morning

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of the 19th. He then found the steamer could not get alongside, the mate reported the barge sinking, a howitzer "took charge" and went overboard, the barge listed and never recovered. With difficulty the mate escaped by a sanpan and the lascars clambered out of her; the barge went down with all stores in 24 feet of water. Major Baker was directed to return to his other barge and escort the *Irrawaddy* and *Ngawoon*. About 4 p.m. Head-Quarters steamed past and signalled "To cast adrift the *Ananda's* barge," saying "You cannot tow her in that way"; she had been brought up alongside, in front of the paddle-box, and was to all appearance, and in the opinion of Capt. Watson, of the *Yunan*, in a very good position. Head-Quarters steamed away and there was no possibility of communicating, the order was obeyed. Anchoring in the evening, I visited the General, reported the loss of the *Ataran* barge, and the great improbability of the *Ananda* being able to rejoin the force. It was evident the steamers were not powerful enough to tow two barges against such a current as runs above Minhla in the Irrawaddy river.

On the 20th Lieut.-Colonel Budgen was away on the *Ataran* as President of a Court of Enquiry on the loss of the barge, and did not return until the evening, when hearing some particulars I was satisfied that the barge foundered without sufficient reason. The following morning, visiting the General on the subject, I explained my belief that the foundering was caused by want of water communication between the pumps with the body of the barge, the pumps being in bow and stern, only pumping those parts out. On this I was allowed two R.E. officers, a party of carpenters, and visited the *Ataran*, when, cutting holes through the gun-deck fore and aft of the centre beam I found eight inches of water in the hold; evidently the water had been gradually accumulating, although the pumps said the barge was dry, and unknown to anyone had been gradually sinking getting deeper into the water day by day.

The *Ananda's* barges were probably in the same condition, and like the Captain of the *Ataran* and Officer Commanding the Battery, those on board these barges would know nothing of the gradual sinking under their feet. It is to be hoped that the Artillery may be excused for this mishap, for although I should have seen to it, yet neither the firm who altered the barges, nor the Port Officer who was responsible for the seaworthiness of the boat nor the Senior Naval Officer, ever thought of this point when the pumps were fitted, and it was left to me to solve the evil after the mishap and loss of a barge.

On the evening of the 21st the *Doowoon* arrived and Head-Quarters removed to her, my adjutant and I moved over to her from the *Yunan*. On the 22nd, in the morning, the *Thanbyadine* was sent to look after the *Ananda*, and I sent a letter by the Captain to the Officer Commanding the R.A. on board to cut through the gun decks of his two barges and bail out, and if necessary after clearing out the ordnance and stores to pitch the laterite overboard and come up as quickly as possible. This letter was only delivered by post after the *Ananda* rejoined the fleet, and after I had issued fresh instructions for the gun-decks being cut through.

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The force passed Pagan about 3 p.m., and about 4 p.m. an enemy's battery, on a high bluff above Nyoungoo opened fire on the Naval Brigade, this was immediately replied to, while the *White Swan* moved up in support and fired four rounds from her two 40-pr. R.M.L. bow guns; about 6 p.m. the enemy withdrew, the Navy landed a party, threw the guns over the cliff and returned to their ships.

In the morning a garrison of two guns of No. 1 Bombay Mountain Battery, Lieut. Stuart; 2 companies of the Liverpool Regiment; 4 companies of the 11th Bengal Infantry; and the 5th company of Bengal Sappers were landed and occupied the site of the enemy's battery. Two of the King's steamers had been beached here but slipped off into deep water and will probably be total losses. The battery was a half sunken one.

On the 23rd it was still raining, there had now been four days of incessant rain, and the *White Swan* reported leakage in her magazines, two barrels of cartridges however only were destroyed.

At 1 p.m. the *Mindoon* arrived and reported the *Ananda's* barges to be in a precarious state and that the Major of Artillery was sticking to his guns and would part with nothing, and having given all assistance came away. He also reported the *Thanbyadine* aground half way. On the 24th the *Mindoon* was sent down to assist those vessels, and at noon the force passed Koonywa on the right bank and in doing so avoided a shore battery by moving up a channel under the left bank. The battery opened fire on the Naval Brigade but soon found it was powerless owing to the increased range. It was a 9-gun battery, the parapet being continued over and above the embrasures, which were also screened with stacks of wood about one hundred yards in front. About 3 p.m. the force made Mingyan, and a 10-gun battery low down in the bed of a creek opened fire on the column. Shortly after passing a small village a solitary screened gun opened fire as the *Irrawaddy* steamed past, broadside on. The *White Swan* and the *Ataran* were moved up in support of the Naval Brigade and a regular action was fully developed.

The town of Mingyan is large, and the batteries and parapets had been thrown up all along the river front and were now occupied in force. The passage had to be forced and the batteries silenced, it was too late to land troops. River navigation was difficult and the advance slow; for some time the enemy's fire was well sustained, and their musketry fire was so heavy at times that the crews of some of the launches had to lie down, while the gun crew of the *Ataran* barge did the same, the men on the deck of the steamer replied with carbine fire over the barge to clear the bank, at no time 300 yards distant. The enemy had the advantage of command over all artillery decks, which being so much below the river banks, prevented the fire from being as effective as it otherwise would have been. The enemy under the Hle-Shin-Atwin-Woon were cleared out of their head-quarter house, Agent's house of the Irrawaddy Flotilla Company, and their artillery and musketry fire ceased after dark about 7 p.m. on the Naval Brigade clearing the batteries, but firing occurred from time to time during the night and was replied to by the *White Swan* from her howitzers.

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In the morning, under cover of the *White Swan* and the *Ataran*, the Naval Brigade returned to escort the force up to the landing places fixed on, and after a few rounds from the *White Swan* and the *Ataran*, which effectually covered the ground, the enemy withdrew altogether. A garrison, similar to that at Nyoungoo and Minhla, consisting of the Head-Quarters of No. 1 Bombay Mountain Battery, Capt. Hewson and Lieut. Elliott; 2 companies of the Liverpool Regiment; 4 companies of the 11th Bengal Infantry; 1 company Bengal Sappers were landed here and occupied the position around the Irrawaddy Flotilla Company's Agent's house. A Whitworth 12-pr. shell was picked up here, so it is evident one such gun was employed in the defence.

The artillery ammunition expended by the R.A. on these days was:—

		Common Shell	Case Shot
24th...	*White Swan*	90	10
	Ataran	16	—
25th...	*White Swan*	17	—
	Ataran	8	—

This was enough to test both boats as to capabilities in action.

The batteries were half sunken, as also the parapets, the guns being placed in water courses or ruts over which the parapet was carried. The protection given was therefore perfect, nothing but a shell in at the embrasure would have any effect, and as before stated our guns were fired from a lower level; what projectiles did not strike the parapet passed harmlessly over and went inland. The moral effect appears to have been great, and it is quite possible that only five of the enemy were wounded as is reported; it is also said we fired torpedoes into the country. The Irrawaddy Flotilla Company's Agent's house was however a perfect wreck. At all events, the firing of this action was heard in Mandalay, 35 miles off, and led to the surrender on the 27th of the month.

The Navy had two 64-pr. R.M.L. guns in action besides the smaller guns of the I.M.S. *Irrawaddy*, steam launch *Kathleen*, while the Artillery had the *White Swan*, 2–40-prs. R.M.L., 6–6·3-inch howitzers, and the *Ataran* barge with 2–6·3-inch howitzers. The Artillery force of 10 heavy guns was therefore far superior in every way to what the Navy were able to show, while, moreover, seven out of the ten were broadside guns. Both Capt. Woodward, R.N., of H.M.S. *Turquoise* and Capt. Clutterbuck, R.N., of H.M.S. *Woodlark*, commanding the *Irrawaddy*, highly complimented me on the working of the Artillery force. It may therefore be said they had no small share in the glory of the day that laid a whole country at England's feet. About 5.30 p.m. on the 25th the force continued its advance and anchored at a spot which was supposed to be barred. On the 26th after reconnoitring, the force again proceeded and was fired on by a solitary gun, the Whitworth 12-pr., but seeing they could make nothing of it, the enemy withdrew, and at 6 p.m. the force anchored about 15 miles below and about west of Ava redoubt called Segone fort. Here the Minister of the Interior, Myoung-Shway-Ah-Kyouk-Nyoung-Atwin-Voon with Oo-Shway-Ah-Watima-Soot-Woundouk came down in a 46-oared boat with a flag of

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truce and asked for terms. He was informed that an unconditional surrender of forts, army, king and country must be given, and that our advance would not be delayed. He felt fully convinced that the General would keep his word; moreover, a steamer he claimed as having come from, being armed, it was boarded and taken, while he returned in his row-boat. It has always been a moot point as to whether we had overhauled the steamer, and he coming down made use of it as a means to take it out of our hands, or whether he came down in her. At all events, on the plea that the steamer was armed, it was taken possession of at once. As there was a possibility of having to fight with both banks of the river on the morrow, I now arranged for six mortars being placed in action on the port and undefended side of the *Yunan*, so that in passing any battery on the right bank it might be shelled.

On the 27th November the force again advanced, and about 9 a.m. passed the Kyoung-myo-daw-gyee or the "Work of Royal Merit" on the right bank; it is merely a pagoda in the shape of a woman's breast. The story is that Soupyalat, the King's first wife, ordered a pagoda to be built there, and being asked of what shape it was to be, just lifting one of her breasts up with her hand said—"there, like that."

The force passed Longgrass Island at 10 a.m., and the leading vessel clearing some trees came in sight of Segone fort, the rest of the fleet gradually coming up to the tope of palms on the left bank, marked out in my Report as the proposed landing place for the force.

The orders given for the attack were issued in Divisional Orders of the 27th November and ran as follows:—

The 3rd Brigade[1], Brigadier-General Norman, C.B., Commanding, will land on the left bank of the Irrawaddy, just above the creek, about half-a-mile from the Ava redoubt, sometimes called Tsin Kyun, and will direct its attack on the S.-W. angle of the town wall, and will endeavour to bring a fire upon the great bridge leading from the town to the south, if Burman soldiers should be crossing it. The object is to drive the King's army eastwards over the Myit-Ngay river, and to prevent retreat to the south.

2. The 3rd Brigade will preserve connection with the 2nd Brigade on its left, and will protect its own right flank during the operations. General Norman will, if possible, advance to the east face of Ava town. If assistance be required he will send a written request to Brigadier-General Ford, Commanding 1st Brigade in reserve, stating the number of troops wanted, the place at which they are required and the object to be attained; if possible an officer of the 3rd Brigade should see the operations performed and report accordingly to the Officer Commanding the 3rd Brigade. It is recommended that close formation shall, as a rule, be preferred to extended order, but the working of scouts should be specially enforced.

3. The 2nd Brigade[2] under the command of Brigadier-General E. S.

[1] The Mounted Corps, Hazara Battery, R. W. Fusiliers, 1st Madras Pioneers, ½ company Sappers.

[2] 9/1, C.P.D., R.A., 2nd Hampshire Regiment, 12th and 23rd Madras Infantry.

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White, V.C., C.B., will land at the same spot and will advance on Tin Kyan, the redoubt west of Ava, the entrance is on the eastern or furthest side, but a path from near the landing place leads to it. Ten planks 30 feet long and ten scaling ladders should be taken; afterwards the city wall should be assaulted on the western face and the enemy driven eastwards across the Myit-Ngay river. Great care should be taken that no accidents occur from explosives. If the redoubt or works be empty a guard should be placed on the entrance and no one allowed to enter till an examining party has reported regarding the position of magazines, and carried out the orders of the Brigadier-General for the destruction of the powder. If assistance is required it will be asked for from the Officer Commanding the 1st Brigade, as directed for the Officer Commanding the 3rd Brigade.

4. The mounted corps will disembark after the 1st Regiment of the 2nd Brigade; its duty will be to reconnoitre Ava redoubt, the western and southern wall of Ava town, the creek called Myit-tha-Choung and the roads on the bank. This choung runs nearly parallel to the south wall of Ava, at a distance of one or one and a half miles from it. It will find the exact position of the great bridge over the Myit-tha-choung, leading to the interior from the south gate of Ava, and if no body of troops is crossing the southern bridge, they will endeavour to obtain information regarding the eastern bridge, that is the bridge over the Myit-Ngay. All information is to be conveyed to the Officer Commanding the 3rd Brigade.

5. The 1st Brigade[1] will land at the same landing place after the 2nd Brigade, and will follow the operations of the leading brigades, the men being kept well in hand for further operations after the fall of Ava proper.

6. There is deep water north of the north-east angle of Ava.

7. The bridge over the Myit-Ngay is not to be destroyed without special orders.

8. The Naval Brigade[2] Captain R. Woodward, R.N., Commanding, will take part in the operations of Ava as under —

a. By a long range fire on Ava redoubt, on the earthworks connecting the redoubt with Ava, and on the N.-W. angle and N. face of the fortifications of Ava, and the pagoda near the N.-E. angle and inside the town called Sankalhyatoo.

b. By a closer fire on the same points, if possible bringing an enfilade fire on the S. front of the town wall of Ava, which, if necessary, can be effected by landing two 25-pr. guns at the point at which the troops land.

c. By an enfilade fire, first on the W. and afterwards on the E. face of Ava town.

d. By breeching the redoubt on the right bank of the river.

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[1] 2 companies Liverpool Regiment, 21st and 25th Madras Infantry, 2 companies Sappers.

[2] I.M.S. *Irrawaddy*, S.S. *Ngawoon*, S.S. *Palow*, Launch *Kathleen*, S.S. *Yunan*, with R.A., and S.S. *Ananda*, with R.A.

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If these operations and the land operations are successful, the redoubt of Thabyadan and the battery on the hill that commands Thabyadan should be bombarded, and a reconnaissance of the Myit-Ngay made if possible. Before the commencement, and during the operations, reconnaissance should be made both of the batteries and of the channels.

9. Place of the Major-General.—The probable position of the Major-General Commanding during the operations will be, first, at landing place, second, at N.-W. angle of the town, and third, at N.-E. angle of Ava town.

10. Maps will be issued on which the route of the 2nd Brigade will be marked in red, and that of the 3rd Brigade in blue.

11. Staff Officers.—Major Symons, D.-A. & Q.-M.-General, will be attached to the 3rd Brigade, and Captain Milne, D.A. & Q.-M.-General, to the 2nd Brigade, as Staff Officers for these operations.

12. Food and ammunition.—The troops will have a substantial breakfast before landing, and take a meat ration and biscuits in their havresacks, water in their water bottles, and seventy rounds of ammunition per man.

13. Officers in command of all corps, batteries, and detachments, are requested to send to Lieut.-Colonel Begbie, as early as practicable, a nominal roll of officers and soldiers employed on visual signalling, and also a list of apparatus in use. The apparatus received from the Superintendent of Signalling to be shown separate from regimental and private property.

By order
(Sd.) H. M. BENGOUGH, *Colonel*,
A.-A. & Q.-M.-General,
Burma Frontier Force.

Any error in these orders was corrected by the plan of advance as shown by the red and blue lines.

It may be noticed here that there is no bridge over the Myit-Ngay, but there is one over the eastern ditch on the east face of Ava. The great bridge south, over the Myit-tha-choung had not been discovered up to the 28th February, and the Myit-tha does not fall into the Irrawaddy so close as is shown, the native maps from which this information was obtained appear to be wrong on this last point. The former was an error of mine in taking a bridge over the ditch of the east of Ava as over the Mit-Ngay, as seen from the steamer's deck.

The flag of truce however now came again to the front. The Minister had waited our arrival rather than row down to meet us. The General now left the *Doowoon* and proceeded to the *Irrawaddy*, and there entered into negotiations.

An unconditional surrender of forts, army, king, and country was admitted, but the army objected, and required royal orders.

No. 1, sent by royal order, ran as follows:—From the Hlot-daw to Bo Hmooken-Atwin Woon, Pen Myo-sa, Myo-thil Atwin Woon, Kyouk Myoung Atwin Woon, Wet ma Soot Woondouk, Pendalai Woondouk. "When the English ships arrive you are on no account to fire on them.

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"Let all the troops keep quiet. Publish this abroad everywhere. The "King concedes unconditionally to all the demands made by the "Commander of the English Forces, as contained in his letter of "yesterday's date. You are to let the English Commander know this "as quickly as possible."—Not being considered sufficient, would not the English advance on to Mandalay and leave the forts alone.

On this 3rd the Brigade prepared to land and the *White Swan* ordered to advance and take up a position with her broadside on the fort.

The enemy, it was discovered, had several batteries below the fort and near the landing place, and I immediately distributed the Artillery as follows, to cover the landing. The *Ashley Eden* 4 Hazara Battery, to cover a second battery just above the landing; while the two howitzers of the *Ataran* bore on two other batteries. The *Shoay-myo* in the meanwhile gradually drew in towards the left bank, followed by the rest of the 3rd Brigade. The *Panthay*, 9/1, C.P.D., R.A., was placed to the right rear of the *Shoay-myo*, commanding a battery down stream below the landing. When the arrangements had been about made it was said the royal order for the army to surrender had been received and the troops were ready to lay down their arms. The 3rd Brigade was then ordered up abreast of the fort to land and take possession; at this time Admiral Sir Fred. Richards, K.C.B., of H.M.S. *Bacchante* arrived with the rest of the Naval Brigade, as also the *Ananda*, Major Broadfoot, 4/1, N.I.D., R.A., with one barge only, the other having been abandoned after being cleared of all guns and stores.

The 3rd Brigade landed and took possession. No Artillery were allowed to land except my Adjutant and I, who went round and, with the assistance of some infantry, unloaded the guns in position and destroyed all gunpowder in the various magazines.

The fort is correctly described in my report of the 16th October, 1885. The interior slope of the parapet had been found too high for field guns to fire over, so three had been placed in gun-pits on the superior slope. Three small wall pieces flanked the rear face from the indented line. Six field guns were in a sunken battery on the bank of the river in a line through the N.-E. and S.-W. angles of the fort, and another battery 50 yards higher up on the bank facing the river. Some days afterwards other batteries were found and disarmed which extended at intervals along the Ava lines, river frontage; the nearest battery below the fort was a ten-gun sunken battery.

The Infantry received orders after the remnant of the enemy's army had laid down their arms, to disarm the works and embark the guns of the several batteries, this was not completed by dark. The Naval Brigade had in the meantime surveyed the channel of obstructions above the fort, and orders had been issued for the disarming and surrender of all guns at Sagaing redoubt and Thabyadan fort by the following morning.

The force went to bed that night conscious of having achieved one of the most bloodless and most successfully worked out campaigns in history, but much disappointed at not having had to fight. Had there

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been fighting there is no doubt but that the broadside of the *White Swan* would have effectually cleared the fort and batteries about, whilst other vessels with their bow guns and howitzers also would have effectually silenced Sagaing redoubt without forcing the barrier, the Infantry, landing at Palm tope would have carried the fort and taken all the works in reverse, right up through Ava to the Myit-Ngay river, *vide* plan. The enemy admitted they had no Artillery to bring against ours, and told Colonel Sladen that the sight of the *White Swan's* broadside had had great effect in forcing the surrender. So closed the 27th—Ava the key of the position in possession of the English.

On the 28th, while the 3rd Brigade continued the disarmament of the batteries with orders to follow up as soon as possible, the *Burma* was sent to take off the guns from Sagaing and batteries above it, on the right bank of the river, while the *Ashley Eden* and the *Ataran* were dropped at Thabyadan fort to disarm that and the Shoaygyet batteries and others on the left bank of the river; Head-Quarters moved on Mandalay at 9 a.m. and without opposition moored in the following order along the bank between *C* and *A* roads and below it. With the exception shown of the two batteries, *vide* diagram, hardly a gun had been mounted on this long line of defence, the possession of which now gave the Army the command of *A*, *B*, *C*, and *D* roads, the only roads to the city by a direct and straight line from the river, *vide* enlarged plan of city from previous report.

The fleet was to have advanced, the *Ataran* following the Naval Brigade and anchoring, to cover the rear and the Yankeentown immediately in her path, passing and mooring off *A* road and seize that point of the embankment so as to secure the safe advance of the rest, while the Naval Brigade covered the head of the columns and was supported by the *White Swan*.

The following Divisional Order, dated the 28th November, had been issued:—

ENTRY INTO MANDALAY.

1. The troops will prepare to land at 11.30 a.m. to day, arrangements as to food to be made accordingly.

2. All ships will be thoroughly cleaned during the absence of the troops on shore.

3. The Hazara Mountain Battery, 2nd Hampshire Regiment, and 1st Madras Pioneers, (the last with complete entrenching equipment), will take with them three days provisions and cooking utensils, bakery and slaughter-house establishment and will remain on duty in the city.

4. The remainder of the troops will return to the steamer this evening.

5. Special orders to Sappers will be given by Commanding R.E.

6. Regiments will take colours and bands.

7. The mounted corps will furnish an escort of six men for three

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separate parties of Sappers, and supply seven ponies for Sapper officers. The remainder will form an escort for the Major-General Commanding.

8. Twenty coolies to *Yunan* for Capt. Curtis and party to be sent for at 6 p.m. in the Arsenal.

9. Troops will enter the city as under :—

1st Brigade.—Brigadier-General Ford, Commanding.

2 Companies Liverpool Regiment 21st and 25th Madras Infantry	By *B* road to S.-E. gate of city, securing S. and E. city gates.

2nd Brigade.—Brigadier-General White, V.C., C.B., Commanding.

9/1, Cinque Ports Division, R.A. 2nd Hants. Regiment. 12th and 25th Madras Infantry.	By *C* road to S. gate of palace, securing S. and E. gates of palace enclosure.

3rd Brigade.—Brigadier-General Norman, Commanding.

Hazara Battery. 1st Royal Welsh Fusiliers. 1st Madras Pioners. ½ Company of Sappers.	By *D* road to W. gate of Palace enclosure, securing also N. gate of palace enclosure and city wall. The 3rd Brigade will precede the 2nd Brigade on *C* road, over the Shway-ta-choung stream, taking the first turn to the left after passing the French Consulate, and debouch 500 yards on *D* road.

Such were the orders. After arrival, the Europeans came down and welcomed us, including Mon. Andrino, the Italian Consul, who had done so much for us. None of them had been hurt although they had had a very anxious time of it. In the meantime a message had been sent up to the palace to say that the troops would march up at noon and that an unconditional surrender was expected as agreed on. At 1·30 p.m. the three columns as arranged advanced by *A*, *B*, and *C* roads. Owing to the force, consequent on the fall in the river, being moored somewhat lower than had been expected, Major-General Prendergast headed the column by *A* road and entered the S. city gate, disarming the guard there. On nearing the palace a company was sent round to the W. gate and another to the E.; near the S. gate the E. palace enclosure gates, stood the mint, magazine, and some rifle and gun-rifling machinery works. Colonel Sladen was sent into the king to demand his surrender. He saw the king, his two queens, and the queen-mother-in-law. The king complained bitterly that he

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knew nothing of all this and had been deserted, and required time to leave, he would go as agreed on. With one delay and another, the Major-General sanctioned a delay until 11 a.m. the following day. A brigade, including the Hazara Battery, under Brigadier-General White, V.C., C.B., remained in possession of the palace gates, Colonel Sladen remained by the king, and no one was allowed to pass in or out without his permission. Unfortunately ladies of the court were to have free ingress and egress by the W. palace gate.

Capt. Curtis and Lieut. Churchill, R.A., with 20 N.-C.-Officers and men of Q/1, R.A., took over the magazine and arsenal stores, with orders to make a complete inventory. This turned out a far more difficult work than was at first expected; the remainder of the troops returned to their ships.

On the 29th about 11 a.m. the troops again paraded, a Brigade marched to the palace, the 3rd remained by the shipping. About noon, the Major-General attended by his staff, entered the palace and advanced to the king, who received him in a small summer house sitting at the gate of a verandah, with his two wives somewhat in rear and the queen-mother.

The behaviour of the royal party was dignified and quiet, the blow had fallen and, it was a complete surprise. The king again entreated for time, which was refused. At last, at 4 p.m., the royal party filed out of the palace. First came the queen-mother, telling her beads, for the buddhists have rosaries, then the king with a queen on either side, and then a crowd of princesses and female attendants with boxes and parcels of various descriptions, laden all over. At the top of the palace steps, when the queen-dowager saw the guard formed up as a lane to pass through, she hesitated. This was a complete surprise, a guard of armed foreign European soldiery to file through; however, recovering herself, she led on to the palace gate and took her seat in one of the country carriages sent for the occasion. The royal procession then moved on, escorted by a brigade of troops, out of the S. gate of the palace stockade and city wall, down in the direction of *B* road to *A* road[1]; unfortunately, about this time the sun set and *A* road was crossed without noticing it, and the error was only found out by the badness of the road, which considering the state of *A* road is saying a good deal. The procession then made a detour, and eventually regained *A* road by the queen's kyoung, and gained the river and shipping at a much later hour than was intended. The royal party, too, must have had a most unpleasant drive, for at this time of the year the roads are at their worst, and those of Mandalay, with the exception of *D* and *C* roads, are execrably bad. *B* road is not quite so bad as *A* road, but that is all, and as to *D* road, the lateral communication to *C* road, W. of the Shway-ta-choung, is across country. The royal party therefore were not to be envied in their drive. Missing the turn was an unfortunate occurrence, but eventually all were safely conducted on board the Irrawaddy Flotilla Company's S.-S. *Thoreah*, which immediately moved out into the stream clear of the shore, and left for Rangoon the next morning.

[1] See plan of Mandalay opposite p. 80, No. 2, Vol. XV.

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In consequence of disturbances in the town by night, fresh arrangements were now made to protect the town from robbery, and extra guards and patrols were placed at commanding points, but it was evident to most that the Burmese local police or authorities had no power to quell it, or no wish to. Infantry picquets gradually extended to the Aracan Pagoda on the S., the Incomparable Pagoda on the E., where a regiment was located, and the embankment on the N., while the city was strongly occupied.

With regard to the Artillery, No. 4 (Hazara) Punjaub Mountain Battery was located at the N. gate of the palace. Captain Burrows with 30 men were placed in charge of the rifle factory, E. of the city.

The Artillery on board the *Ananda* and *Ataran*, lying off the spot, I found a royal dockyard establishment, and occupied it. While Lieut. Cooper, afterwards relieved by Lieut. Anderson with 20 men, occupied the gun factory and powder mills N.-W. of the city.

With regard to these establishments, on taking possession of them, they were all found in the hands of the Burmese, who were busily engaged in plundering them. It soon became evident that the robbers were the soldier guards and workmen of the respective establishments.

I superintended the taking over of all but the dockyard, which I visited later, and in every case made the headmen of the village close by bring back what stolen property was in their possession. In one instance the *finale* was rather amusing; with a party of six gunners I accompanied the headman to his village and told him to direct his people, blacksmiths, to disgorge their ill-gotten gains; on his declining, his arms were pinioned, the neighbouring villagers told his people they ought to be ashamed of themselves for not returning the property, seeing their headman was in such a plight. The women came and told the men to return it, at last he himself gave in and ordered the men to bring all stolen property and lay it down in the square. When all was brought he was told his men must take it back to the place whence they had taken it; and another stand was made; but it was done, and the women folk then turned on husbands and brothers for having been such fools as to bring it away and chaffed them, and the affair ended in laughter. The headman was now released and told to keep order, and the reply was, "There is no government, and no one to put me in authority." I explained that he had been placed in authority by his own native government to keep order, and he had no right to give up that authority without orders. He was now reinstated, and if he had not power to keep down robbery, he must send to the soldiers at the gun factory for assistance. He was perfectly contented.

At a village the inhabitants of a village looted the gunpowder mills, the same nearly occurred, but in this case a daughter of the obstinate headman rated him soundly for not immediately complying with the request to return all stolen property. He gave in, and some ten cart-loads of stuff were replaced, and his authority restored to him. While at the dockyard the scene only varied a little, in that a headman of ten houses who was brought on the scene explained that his neighbours were as bad as himself and that he now had no authority, the government having been removed; and further he did not know the number

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on the houses in which the headmen, his neighbours, lived; on my suddenly asking him "If he thought me a fool," he immediately gave in, the names of three headmen and their addresses were given and the men sent for, and immediate consent for the return of stolen property was agreed to and in all cases more or less carried out. In every case these men were satisfied with their re-instatement in village authority with orders to apply to the neighbouring troops for assistance to stop dacoity; but in my inspection of the several factories, including the saw-mills, iron foundry, and workshops at the end of *C* road, which latter had been out of work for some time, found the custom was, so soon as a factory stopped working to loot all brass work and such parts as could be carried off. No doubt the workmen received little or no pay, the supervision was next to *nil*, and everyone considered himself entitled to what he could take. The machinery was excellent; three gunmetal guns and an iron one were found in the lathes of the gun factory, while another was in the rifle factory, several in lathes in the palace, besides ten torpedoes or sub-marine mines. Inventories of all these establishments were made out by the officers placed in charge and submitted to the G.O.C. I also, with a small column of Artillery, moved out and brought in six elephants from the villages on the N. of the city. This was the first batch brought in. I also took over the saltpetre factory from a native, situated about 400 yards N. of the gun factory, on the 13th December; it was the only one handed over intact. It contained refining pans and large quantities of sulphur and saltpetre in various stages of refinement.

Q/1, R.A., still remained on board the *Yunan*, and besides furnishing some of these parties, marched to and round Amarapura, lying five miles S., and in doing so disarmed a body of men they came across. 9/1, C.P.D., R.A., were on board the *Panthay*, the mule and guns disembarked and encamped on the river bank, and the battery was now called on to furnish a division of two guns, one to each of two columns. One on the 8th marched N. about 15 miles and circled E., returning by the E. gate, the other on the 7th moved S. and circling E. came in by the S.E. angle. These columns were out about five days, they found the roads hardly passable and moving consequently exceedingly slow and difficult. The Artillery with the northern column were attacked with cholera immediately on their return and lost 13 men, when it died out. This battery moved to the E. of Mandalay hill and was very well located, but after that were incessantly on the move. 4/1, N.I.D., R.A., and 3/1, S.I.D., R.A., with the exception of a detachment at one of the factories, were engaged at the dockyard, and in destroying guns down at Ava.

Lieut. Anderson, in charge of the gun factory, was called on by the inhabitants of a neighbouring village to assist against dacoits. He moved out on the 7th with 13 gunners and followed them up about four miles, attacking them in a village, killing two. The villagers told me that seven had been shot. This was really the first brush outside Mandalay embankment.

About this date I revisited the Thabyadan, Ava, and Sagaing forts,

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and Ava lines, with Lieut.-General (now Sir Harry) Prendergast, and on doing so found little to alter in my report of the 16th October.[1]

Thabyadan is not quite what is there traced. It would be better described as a square fort with the S.-W. angle cut off by an indented line, and an outer and lower work along those two sides as altered. The indented sides might be slightly longer but not much otherwise, the fort is as before described in Report of 16th October.

3/1, S.D., R.A., was now ordered up to the palace on the 11th December with two 6·3-inch howitzers and four 25-pr. R.M.L. guns, which the Naval Brigade handed over to the R.A., and six 5½-inch mortars. A squadron of the 2nd Madras Light Cavalry joined the force on the 13th December, while on the 15th Mr. Bernard, the Chief Commissioner arrived.

Lieut.-Colonel Budgen, R.A., was appointed Prize Agent, while on the 16th arrangements were made for the Bhamo Expedition.

The Head-Quarters, 4/1, N.I.D., R.A., Major Broadfoot, were to embark on a flat with two 6·3-inch howitzers and two 25-pr. R.M.L. guns to be received from the Navy together with six 5½-inch mortars. The remainder of the battery with two more 6·3-inch howitzers and two 25-pr. R.M.L. guns were moved to the palace. The Hazara battery moving down to the river ready for embarking with 4/1, N.I.D., R.A., 450 coolies were told off to it. A division of the battery embarked in the *Aloung Pyah* under General Norman on the 7th and proceeded to Mout-Shway-boo, force 600 men—object, to capture a Pretender, a Prince, who to save his life had turned a *Noungyee* when Theebaw had come to the throne.

The Bhamo force, in six vessels, got under weigh about 1 p.m. on the 19th December.

In making these arrangements the barge of the *Ananda* was disarmed and her 40-prs. placed on board the *White Swan*. The barge itself going back to Rangoon with the steamer carrying Mons. Haas, the French Consul, his baggage and all the laterite earth that came up in the barge went back in her. With regard to this gentleman, his scheme for French aggrandisement broke down at the time that I visited Mandalay, and both these gentlemen leaving the Burmese capital together, a Burmese court rumour got about that "Colonel "Carey had come up and carried him off a prisoner to Rangoon, and "handed him over to the Chief Commissioner." The latter officer on hearing of his arrival having hospitably taken him into his house. After this date Mons. Haas entirely disappears from the scene.

Q/1, R.A., with the *White Swan* and her armament was ordered down to Rangoon as no longer required.

On the 20th the Bhamo force, which included the Naval Brigade, Capt. Woodward, R.N., with Major Hewett of Q/1, R.A., his interpreter, picked up the *Aloung Pyah*, and Brigadier-General Norman, with a portion of the Hampshire Regiment and the division of the Hazara battery transferred themselves to the *Palow*. Mout-Shway-boo had been occupied and the force now proceeded up the difficult passage of the Irrawaddy.

[1] See Plan opposite p. 75, No. 2, Vol. XV.

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On the 21st the Head-Quarters in the *Thanbyadine* arrived off Segoon and inspected the Burman telegraph office and communicating with Lieut. Holloway of the 2nd Madras Light Cavalry who had come by land as escort to a party repairing the line; it was so damaged as to necessitate their making a return trip.

Whilst waiting for the remainder of the force to assemble, a village on the opposite bank applied for assistance against dacoits; a dismounted party of Cavalry, with Captain Aldworth, A.-D.-C., and Captain Adamson, Political Agent, were sent over and captured 20 dacoits, of whom 3 were shot, 3 sentenced to imprisonment, and the rest received twenty lashes each and were then released.

The force having re-united started again at daylight on the 23rd and called at Mali, the Woon of which place was reported to have gone off as a dacoit with 300 followers. His factotum was appointed Woon in his stead over five villages. On the 24th the force called at Teigeik on the right bank opposite Myadoung. It is a beautifully wooded bluff commanding the river N. and S. The headman appeared glad to see us and the inhabitants were engaged in stockading the village. Close to the village was a tiger trap which consisted of two bamboos lashed together at the head, with a piece of bait hanging from the end of a cross bamboo weighted at the other end, the weight being suspended over a concealed hole. A tiger is said to have been caught there a few days before our arrival. The village possesses a very fine race of bantam poultry and is one of the most picturesque spots on the river.

On the 25th the force assembled here, and the Staff dined together on board the Head-Quarter steamer. At noon on the 26th the force called in at Katha-a-Shan a Burman village, where owing to race hatred, and not being able to trust each other, the inhabitants live at opposite ends and stockade their own portions not only against dacoits and a common enemy, but against surprise from either party. This is one of the strongest stockades in Burma. The system is a diagonal bamboo lacing about 6 inches square, with tree or post supports at regular intervals; three horizontal bars of bamboo or young trees are laced to this with bamboo strips passed diagonally over and under, both ends of the bamboo are pointed and project about 18 inches, in fact present a perfect *chevaux-de-frise*. An outer stockade with 9-inch squares is put up some fifteen feet in front, the intervening ground being studded with bamboo stakes or crow's feet. The gateway is proportionately strong and double, one half only is opened at a time, and that only partially. Evidently no one was to be trusted. Both races are interesting and were civil to us.

On the 27th the force visited Shwaygoo, a rather large Burman village with a dockyard and timber yard, it is also noted for its pottery.

The second defile was entered in the course of the day, and is narrower than the first defile, which probably is so called from the extra depth of water between the banks, but the banks are not notably higher than the lower part of the river. In the second defile one cliff rises perpendicularly to about 800 feet, and the river is much narrower; it is well worth a visit.

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About 4 p.m. on the 27th the Head-Quarter vessel made Swagee but having got into a *cul-de-sac* dropped down to Kodoon-myo, at both places a few young men let off their muskets at us, as this was considered mere bluster, a boat was sent off to speak to them, and they explained they were afraid and thought a shot might warn us off. They were not molested except by the electric light playing on them from the survey vessel of the Naval Brigade, which joined us towards evening, this must have astonished them a little.

On the morning of the 28th the headman of Koodown-myo came on board with a messenger from the Woondoak at Bhamo, to whom he had reported our arrival. The messenger welcomed us, and we proceeded, anchoring about 1½ miles below the town, the river being too low for us to go up higher. The Woondoak came on board and paid his respects to the General, stating the town and country was his, and returned on shore. The General landed with his Staff in the course of the day, walked over the town, which is about one mile long, and in the centre is about 500 yards wide and not more than 60 yards at each end, surrounded by a 10-inch stockade of teak.

The Chinese live N. of the cross road running E. while the Burmese occupy the centre and S. half of the town. The centre contains the Woon's house and Kyoungs. The Woondoak's house is on the river bank. Altogether eighteen guns were found in the town. The entry was made exactly one month after the capture of Mandalay. In the evening the party returned to the ship, and the *Pulu* joined us. Consequent on not being able to move further up river, the next morning these vessels dropped down about three miles and made fast alongside a high bank covered with jungle or elephant grass. With difficulty a road was cut through to the country road towards Bhamo and turned into a tolerable road. Two companies of the Madras Infantry were moved up to the town on the 30th and occupied the Woon's house, while on the 31st 4/1, N.I.D., R.A., landed two 25-pr. R.M.L. guns with a trench cart, gyn, &c., to send up by road to the cantonment. The Navy handed over two more 25-pr. R.M.L. guns to the Artillery. On the 1st January, at 7 a.m., 4/1, N.I.D., R.A., assisted by a party of the Hampshire Regt., moved the two 25-prs. by road to the stream half way to Bhamo, arriving there about 11 a.m., the gunners breakfasted and the infantry returned to their ships about 1 p.m., a second party joined the Artillery, and took the guns across the stream. The road out was very soft and the gyn had to be used twice to get over bad bits of ground, but having crossed the ford the guns and gyn cart sank in the sands. A party of sappers under Captain Cairns, R.E., worked right well in preparing jungle grass for a roadway to the bank on which everything was safely landed by 4.30 p.m.; here a party of 80 men of the 4th Punjaub Hazara battery which had moved to cantonments, passing the guns at 11 a.m., returned and took the two guns into camp. I rode on with them, but sent the Artillery and Infantry back to their ships. The guns got into camp at 6.30 p.m., after a hard days work.

Colonel Bengough, A.-A.-G., with a reconnoitring party moved out to meet some Shan Chiefs on the 31st, and returned the 3rd or 4th day after a fairly satisfactory interview.

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On the 4th January the *Palow* was cleared of Artillery, two 25-prs. and two 6·3-inch howitzers and all artillery stores were transferred to the reserve flat. All shell, except 100 sent up by road, were now sent up by boat to Bhamo to the artillery store.

A Committee assembled on the 5th January to fix on a site for the cantonment and fortified post:—

President.—Lieut.-General Sir Harry Prendergast, K.C.B.

Members.
- Brigadier-General Norman, C.B.,
- Colonel Carey, R.A.,
- Colonel Sandford, R.E.,
- Surgeon-Major Libthorpe, A.M.D.,
- Senior Medical Officer, Bhamo.

The centre portion of the town being occupied it was decided that the E. face should be protected by three artillery 2-gun batteries at N.-E. and S.-E. angles, and one between both. A capital central position was found for a general magazine, on a knoll with a natural ditch nearly all round it. The rear of the cantonment was to be stockaded against the town, and the Hazara battery was considered sufficient to defend those sides if necessary.

6th January—The remainder of the Infantry and 4/1, N.I.D., R.A., moved by road to Bhamo, Brigadier-General Norman and his Staff by water. The Head-Quarters returned towards Mandalay and arrived there at 1 p.m. on the 12th. Here the garrison had been busy in sending out various columns to put down dacoity, in which 9/1, C.P.D., R.A., had not been idle. The following table gives the various columns they were out with:—

Number of guns and Division.	Date of		Memo., or order in which the column was detailed.	Number of animals supplied as transport to other Corps.	Remarks.
	March.	Return.			
2 Right.	7. 12. 85.	14. 12. 85.	D. O. 6 o'clock of 6th.	—	—
2 Left.	8. 12. 85.	14. 12. 85.	D. O. 11 o'clock of 7th.	—	—
2 Centre.	22. 12. 86.	5. 1. 86.	G. O. 3 o'clock of 21st.	6	—
2 Right.	29. 12. 85.	29. 12. 85.	G. O. 1 o'clock of 28th.	12	—
Nil.	—	—	G. O. 1 o'clock of 31st.	5	—
2 Left.	2. 1. 86.	4. 1. 86.	G. O. 9 o'clock of 1st.	12	—
2 Right.	7. 1. 86.	13. 1. 86.	G. O. 1 o'clock of 6th.	9	—
2 Left.	9. 1. 86.	11. 1. 86.	G. O. 1 o'clock of 8th.	7	—
2 —	15. 1. 86.	—	Do.	2	Mout Shum Bo.
2 —	19. 1. 86.	25. 1. 86.	Do.	—	Kank say.
2 —	2. 1. 86.	—	Do.	—	Aloung myo Chindwin.

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A division was hardly in before it was ordered out again, and as will be seen it had been called on to supply transport for the infantry, the mules were overworked and the necessary gun and other reliefs not allowed. On my representing this it was altered, the transport had to supply the infantry, and when a division was ordered on detachment it marched complete, except tents, which were left in Mandalay, all troops being housed in Kyoungs; under these arrangements the mules rapidly improved. I however found it necessary to detach 20 N.-C.-Officers and men from 3/1, S.D., R.A., for duty with 9/1 C.P.D., the battery with 14 deaths from cholera and sickness being unable to keep the divisions complete.

The coolie batteries proved a failure. Mules were telegraphed for; those of the Bombay Mountain Battery arrived about the 1st March, those of the Hazara battery about the 6th.

The R.E. took the palace in hand and strengthened the defence by throwing out caponiers from the centre of each side of the stockade to give flank defence, and adding a platform at each angle to enable infantry to fire over the stockade and command the four cross roads.

It was also proposed by a Committee to build a redoubt on the embankment above the commissariat stores at the landing place *A* road, to be armed with two 6·3-inch howitzers and two 25-pr. R.M.L. guns. The armament proposed afterwards for the Palace stockade was six 68-pr. carronades, and six 32-pr. S.B. guns on garrison or other suitable carriages, 24 in all. These guns being merely for sweeping the streets with a range of not more than half a mile, a proportion of 75 p.c. of case shot was recommended as part of the ammunition. A stockaded guard room was erected in *B* road commanding the four cross roads and Chinese bazaar.

The country was now occupied with garrisons as follows—date 23rd March.

Bhamo,	Myotha,	{Pagan, Yonanyoung,
Mogamig,	Mymgyan,	
Kettah,	Mahline,	Sinbaungway,
Shwebo,	Samaitkyou,	Thagi,
Kyauk-myoung,	Natogi,	Segu,
Singu,	Pokkungyee,	{Sinpujun, Salenmyo,
Modaya,	Pakoko,	
Mandalay,	Popa,	Magway,
Ava,	Pagan,	Mingun,
Sagaing,	Singun,	Sakomyo,
Yawkuntown,	Letham,	Mapemyo,
Kanksay,	Minhla,	Mimbo,
Alaun on Chindwin,	Poalparmyo,	

White troops from Lower Burmah occupied Toungdwengyee, Mingyan, Zemethen, Hlundel, the three latter on the Toungoo-Mandalay road.

On the 11th February their Excellencies the Viceroy and the Commander-in-Chief of India arrived, and after a few days stay returned on the 18th of the month.

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Lord Dufferin invited Sir Harry Prendergast and his Staff to dinner on the 17th, and in a speech explained that Sir Harry's orders were to proceed to Mandalay as quickly as possible and not to fight more than was absolutely necessary. The aim was the capture of Mandalay, the king and royal family, but we had no quarrel with the people of the country. He also announced a gratuity to the troops in lieu of both batta and prize, Rs.300,000 for the army. This latter announcement was not received with cheers.

Sir Harry was appointed to command all the troops in Burma and Colonel Carey to command the Artillery in Burma. This force was now reduced by—

Q/1, R.A., from Rangoon to St. Thomas' Mount.

3/1, S.D., R.A., from Mandalay to Barrackpore.

4/1, N.I.D., R.A., from Mandalay and Bhamo to Fort St. George.

5/1, S.D., R.A., from Thayetmyo was ordered to relieve 4/1, N.I.D., R.A., ⅓rd going to Bhamo, Head-Quarters with remainder going to Mandalay.

The Artillery force in Burma was now reduced from ten to seven batteries, as follows:—

⅓rd of 5/1, S.D., R.A., and Hazara Mountain Battery, Bhamo.

⅔rds of 5/1, S.D., R.A., Mandalay,

9/1, C.P.D., R.A., { Head-Quarters, Mandalay, / 2 guns, { Mount Shaybo, / Aloungmyo on Chindwin, / Kouksay,

No. 1 Bombay Mountain Battery,—Head-Quarters and 2 guns at Mingyan, and 2 guns at Nyoungoo and Alinemyo.

3/1, S.I.D., R.A., Head-Quarters 4 guns Thayetmyo and 2 guns Toungdwmgyee.

8/1, L.D., R.A., Head-Quarters elephant battery, 2 guns at Yemethen, 2 guns at Ningyan, and garrison portion of battery, Fort Toungoo.

6/1, S.D., R.A., Head-Quarters Rangoon, and Det. of 25 men and 1 officer Thayetmyo fort.

Brigadier-General E. S. White, V.C., C.B., was given the Command of the Mandalay Brigade, and Lieut.-Colonel Budgen, R.A., that of the R.A. Brigadier-General Norman, C.B., Commanded at Bhamo. These orders were afterwards cancelled by the Home Government, by the recall of Lieut.-General Sir Harry Prendergast, V.C., K.C.B., from the 1st April, from which date the Lower Burma Division was to be reconstituted as before; later on the boundary line for the command was also fixed at that. Brigadier-General White, with local rank of Major-General, was given command of the Burma Field Force. Lieut.-Colonel Budgen, R.A., thus came into command of the R.A., B.F.F., now including Head-Quarters, Field portion of 8/1 L.D., R.A., and a division of 3/1, S.I.D., R.A., at Toungdwmygee, still later on 7/1, N.D., R.A., was added, making his force about six batteries, while my force consisted of the Head-Quarters of two batteries and a detachment of a third, not two whole batteries.

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Brigadier-General B. T. Gordon, C.B., took over the Command of the Burma Division, while the force in the whole country was increased by the middle of May to about 23,000 of all arms, and Sir Harry returned to India on the 4th April.

On two or three occasions for want of other artillery detachments of Garrison Artillery, an officer and 21 N.-C.-Officers and men, with two mortars fitted on improvised mortar saddles and placed on ponies of the country, were sent out. The attempt, although a very good one, mostly worked out by Captain Cather, R.E. in charge of Transport workshops, was however not a success, the ponies were found too small and the trouble of keeping the mortars and saddles from turning round on the pony, and guarding them, with the very small chance of using them, showed they were not as a rule worth the carriage. The only place they might have been useful was at Wentho, a strong stockade, but the chief gave in and the column returned. Wentho is said to be strongly stockaded and has a brick wall. On no occasion were these mortars ever brought into action.

The following is a return of ordnance captured up to the 31st January 1886, of which no less than 1546 were found in the palace.

Date.	Names of Places.	Iron guns.		Brass, Copper, or Bronze.		Total.	Total.
		Cast.	Rifled.	Guns.	Mortars.		
13 Nov.	Nyoungbin Man	8	—	—	—	—	8
17 „	Khooleygone Fort	12	—	6	—	3	21
—	Minhla	16	—	6	—	2	24
21 Nov.	Myoungoo or Pagan...	5	—	2	—	4	11
24 „	Mingyan	21	—	—	—	—	21
25 „	Pakoko	7	—	—	—	—	7
26 „	King's War Steamer	6	—	—	—	—	6
27 „	Ava Redoubt	3	—	—	—	—	3
—	Ava Lines and Palace	25	—	—	—	—	25
—	Ava Lines	31	—	—	—	—	31
—	Sagaing Redoubt	11	—	3	—	5	19
—	Thabyadan	12	—	8	—	3	23
28 Nov.	On riverbank, Mandalay... ...	7	—	—	—	—	7
—	Mandalay Palace	1363	8	158	17	—	1546
30 Nov.	In Gun Factory	2	—	3	—	—	5
28 Dec.	Bhamo	13	—	—	—	2	15
31 Jan.	Other places	16	1	24	—	2	43
	Total	1560	9	210	17	21	1815
31 „	Add list E. Mandalay	—	—	—	—	—	43
	Grand Total	1560*	9	210	17	21	1858

* Of these 369 are wall pieces.

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The list includes guns of all sizes, and some are of very ancient date, including iron breech-loading guns of the most primitive description. They vary from 1-prs. to those throwing shot probably of sixty pounds weight. A 24-pr. howitzer of English make, besides Dutch, French, and other foreign guns are amongst them, all or any of which are better than the pop guns they armed the batteries with; why none were used is difficult to say; five 32-prs. mounted on traversing platforms, were found in the palace as well as a large assortment of European iron rifled guns of peculiar varieties. Some 9-prs., nine or ten, mounted on field carriages, every part of which was carefully gilded, were called the royal and invincible guns. One gun in particular, carefully gilt, was carried on a four-wheeled gilt carriage with a kind of wooden pagoda covering, all gilded. This gun, owing to the story attached to it, and which was given to me as a fact, ran—

"A holy Moungyee on the approaching outbreak of the war, with a certain amount of religious ceremony, poured a bottle of spirit into the mouth of the gun, saying that if the Burmese were to be victorious the gun would retain the liquor, otherwise it would vomit it forth. The gun finding the liquor too strong belched it forth at once." When the Moungyee was asked how this was done, he replied "the ngats did it." The hint however was not taken, neither the one not to move the great image of Guatama from Amarapura to Mandalay, the weight of which was over 40 tons, and which was barely set up on its pedestal before the English entered Mandalay. In raising this figure on to the pedestal a strong inclined plane had to be built, and the figure standing erect on a wooden platform was hauled up by means of shot running in shotways under it, which as they rolled out below were carried forward and dropped in the way forward. I was told this before the outbreak of the war.

Captain Curtis and Lieut. Churchill, R.A., no doubt will be able to give some interesting descriptions of the more peculiar guns found in Mandalay, amongst which, for instance, five guns were found shaped as a dragon with an open mouth and a body protected with scales.

With regard to the city after entrance, in the course of inspection, I paced the ditch and found it nearly 90 yards in width. The wall buttresses, rectangular projections for flank defence, are nine yards deep by fifteen long. The four angles or bastions are measured eleven yards from the angle of the square, along the side, when the flank is thrown out at right angles like the buttresses, nine yards and the length of the face parallel to that of the square is twenty yards. The city wall is 2245 yards long, city area 1000 acres, palace area 100 acres.

There are three gateways on each face, two buttresses between the gateways, but only one bridge on each side opposite the centre gate, except on the west side where a bridge is placed opposite the southern gate, called the criminal's gate, through which all except members of royalty, who had the misfortune to be condemned to death were led out to execution, hence its name. With regard to the wall it is of masonry, twelve feet thick on the top, with a terreplein of earth quite 40

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feet thick behind it, perhaps not far short of 45 feet, besides a slope to the rear. Fifty yards of clear ground was kept all round between the rampart and the town inside the city. The wall is about thirty feet high.

In closing I may give an extract of my report of the operations.

With regard to the officers and Batteries of the force I never met a more willing or harder working set. One and all were called from different parts of India and embarked on a class of boat fitted for fighting with land siege train Artillery. No sooner did they arrive than they were called on to embark these guns, and then sailed with the curious craft. The whole was done in the exceedingly short time of five days, with the greatest cheerfulness and to my satisfaction. When all worked so hard there is not room for selection, I have, therefore, only to add &c., &c.

To this was appended list of officers brought to notice, including Lieut.-Colonel Budgen, all officers commanding batteries and some others.

Rangoon,
31st May, 1886.

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GRANT'S APPARATUS FOR THE AUTOMATIC SIGHTING OF HEAVY GUNS ON HIGH SITES.

COMMUNICATED BY

COLONEL J. B. RICHARDSON, R.A.

A VERY simple method of automatically sighting heavy guns mounted on elevated sites in Coast Batteries has been brought forward by Captain J. G. Grant, Forfarshire Artillery Volunteers, which if it works in practice as well as it looks on paper, will perfect the quality of fire from such batteries, for it will ensure the sights of a gun being regulated to the exact elevation necessary for its projectile to strike an opposing vessel, without any calculation, loss of time, or necessity for knowing the range.

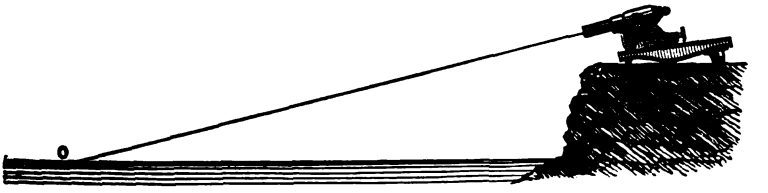
In his specification dated 1st June, 1886, Captain Grant states "With this apparatus the objects sought are—

1st. To enable a person laying a gun to do so as accurately and quickly at unknown ranges as one can lay a gun when the range and elevation are known.

2nd. To show the actual distance of the object on which the gun is laid."

This is attained by the use of two sights, differing from the ordinary arrangement of the service sights, in the fore-sight being made the moveable sight, it being permitted to slide up and down freely in some sort of socket attached to the trunnions, with which it revolves, while the hind sight is fixed. Deflection could be given on whichever sight is found most convenient.

FIG. I.



The fore (or trunnion) sight, which may be either outside or inside the cheek of the carriage, is supported at its lower end on a graduated arc, the curve of which is so designed that when the gun is directed by the sights on the water line of any object within range, it pushes the trunnion sight into the position which gives the correct elevation. Thus:—If a gun is laid at an object *O* within the point blank range of the gun, the line of sight would be parallel to the axis, and the bottom of the trunnion sight would be resting on the top of the graduated arc *A*, Fig. I.

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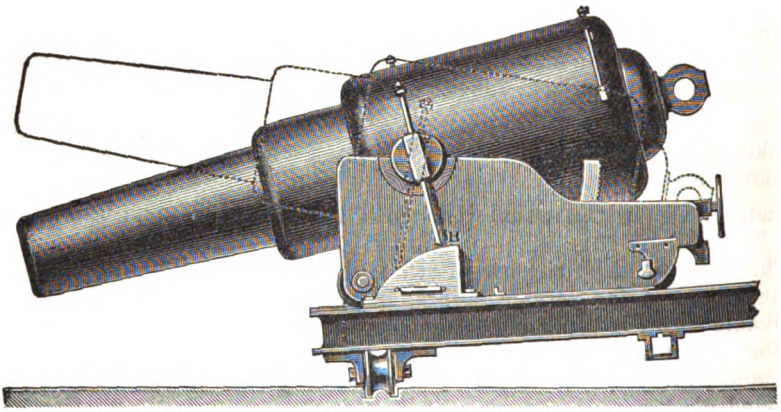
Suppose *O* moves say 3,000 yards away from the gun then, though the axis of the piece could be aligned on *O* by the sights, elevation in addition is needed to enable the projectile to reach *O*. This necessary elevation is given with the service sights by raising the hind sight to a degree ascertained from range tables issued with the gun, which range tables have been compiled elsewhere, perhaps at a different level and under conditions, climatic or otherwise, which differ from those of the gun to which it is sought to apply them in practice. In this invention elevation is obtained by sinking the trunnion sight automatically to an amount which can, in the first instance, be approximately calculated from the range tables, but which can be adjusted to the local conditions, to a nicety, by the experience of actual practice whenever the gun to which the apparatus is attached is fired at a known range. The amount which the trunnion-sight requires to be sunk to give the correct elevation for different ranges forms a regular curve, and to a similar curve the chisel point on the lower end of the trunnion sight bar (*B*, Fig. II.) is applied, this part of the

FIG. II.

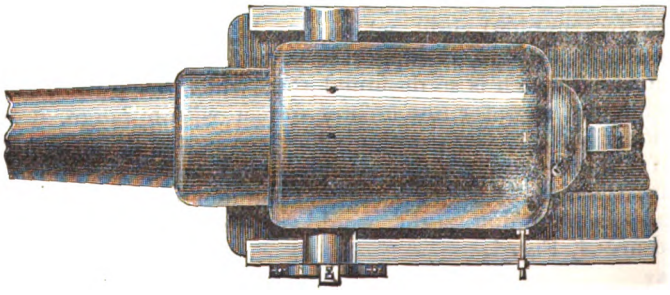


apparatus being fixed to the bottom of the cheek of the carriage. The trunnion sight is inclined from the perpendicular to counteract drift, and deflection is proposed to be given on the hind-sight.

The fore-sight may be either outside or inside the cheek of the carriage the general principle of the invention is the same.

The hind-sight does not require to be of the ordinary pattern. A

FIG. III.



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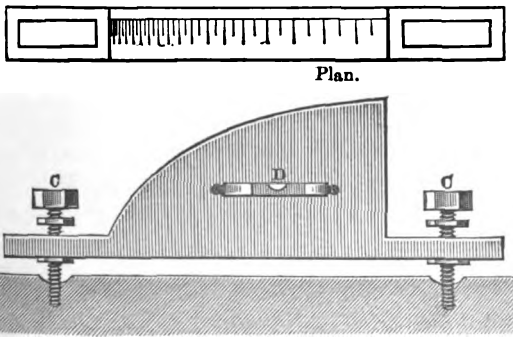
bar with a sliding leaf, something like that of French's sights would do equally well and it has this advantage, that it could be placed in one of the existing sockets and greatly aid in firing at a moving object.

The face of the scale would probably be made of steel, or soft iron case-hardened, to prevent wear. Its base is slotted at both ends and through the slots two screw nuts pass.

The effect of the tide, in altering the elevation of the water line is counteracted by the use of a fixed distance mark in the water, on which the gun can be laid, the curved scale being capable of being raised or lowered as required, as well as being moved forwards and backwards by the use of the screw nuts (*C C*, Fig. IV.) and a spirit level is attached to level it by. (*D*, Fig. IV.)

FIG. IV.



Plan.

Elevation.

To adjust the scale :—The gun is first laid correctly on the distance point with the ordinary sights.

2nd. The scale is slid along under the trunnion sight till the chisel point coincides with the range mark of the distance point.

3rd. The curve is then elevated by means of the two screw nuts until the two lines of sight agree, care being taken to keep the bubble of the spirit level in the centre. It is then clamped in position.

Difficulties may occur in the use of such a system of laying; the idea is however so simple, and if practical, would so greatly aid an artillery-man in working guns on high sites, the addition to existing material being but slight, that the invention appears well worth a trial.

It is evident that the system might readily be applied to laying the guns with an ordinary telescope provided with cross-wires.

The advantage of being able to utilize every round fired in the correction of the sighting of the particular gun would be very great. If a few points in the curve are found by actual practice, no range tables would be necessary. The moveable sight in passing down through the trunnion socket shows on it in figures the distance from the gun in yards of the intersection of the trajectory with the line of sight at the water level.

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PROPOSED HYDRAULIC METHOD OF MOUNTING ORDNANCE.

BY

LIEUTENANT F. R. MAUNSELL, R.A.

It is evident, from the great improvements in the power and accuracy of modern ordnance, as well as the increased development of machine gun fire, that the system which has hitherto obtained of mounting guns *en barbette*, or in armour-plated batteries, must be replaced by some new system of disappearing gun carriage allowing the gun to descend out of sight after firing, and which exposes neither the men nor *matériel* to the searching fire of the enemy.

There are several systems of disappearing carriages already in the service fulfilling these conditions. There are two separate systems of Colonel Moncrieff, one with a counterweight absorbing the recoil and capable of being employed with guns up to the 9-inch R.M.L., and the other a hydro-pneumatic carriage, at present in use only in the siege train.

The system now proposed is one which allows the gun and carriage to sink out of sight, and protects the detachment from even vertical fire except for a few moments. It consists in placing the gun and carriage on an iron platform in a circular emplacement. This platform and the weight of the gun and gear is supported on hydraulic rams. The pressure on these rams is balanced by an equal pressure in an hydraulic accumulator with which the rams are connected, the pressure in the accumulator being got up in the usual manner by heavy weights pressing down on the head.

The pressure on the rams and in the accumulator are nearly equal, that in the accumulator being slightly the greater, and the two pressures form a sort of hydraulic balance. In Fig. 1, the gun and carriage are represented as resting on the platform A. This platform rests on four hydraulic rams, the cylinders of which are sunk in the floor of the emplacement, and the length of whose stroke represents the depth to which the gun sinks out of sight; in this case, the total depth of the emplacement is 12 feet 6 inches, and the length of the pistons of the rams is 10 feet. These dimensions would vary with the size of the gun, which is taken in this case to be an 8-inch B. L. gun.

The ram cylinders are connected by means of copper pipes with the accumulator, and with each other. The accumulator is situated in some safe position in rear of the gun, under cover from the enemy's fire. In the emplacement, and situated conveniently at the side of it, is a hand pump. This is an ordinary hand forcing pump, and is connected both with the accumulator and with the hydraulic rams

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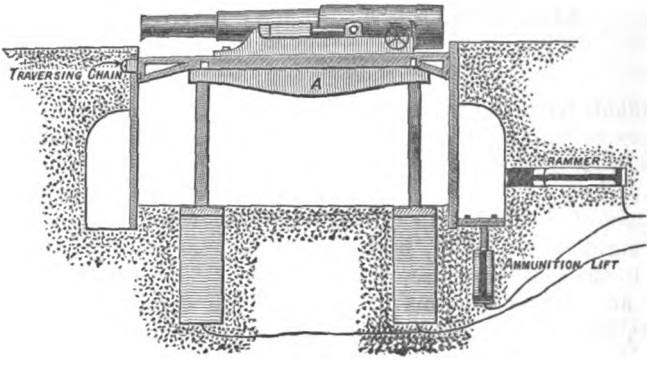
under the platform, and with suitable valves, so that the pressure which it generates can be applied to either. The platform can be raised up and down in the emplacement, and there are guide bars and small wheels bearing against them to guide it as it rises.

FIG. 1.

8-INCH B. L. GUN ON DISAPPEARING CARRIAGE, WORKED BY HYDRAULIC POWER.



When the gun has been fired, and it is required to lower it for loading again, the hand pump is placed in connection with the rams, and worked so as to apply its pressure to them. The rams sink under this pressure and the accumulator rises, and thus the gun is lowered to the bottom of the emplacement into a position for loading again.

Similarly, when the gun is loaded, the pressure from the hand pump is shut off from the rams, and is applied to the accumulator, and the rams raise the gun again into the position for firing. The accumulator and the rams being in a position of equilibrium, very little pressure is required to be got up in the hand pump to raise or lower the gun and platform. In fact the accumulator and rams may be compared to two equal weights suspended from the arms of an ordinary balance; very little pressure being required on either arm to tilt the end up or down.

When the platform is raised into the firing position it is allowed to descend slightly, and rest on supporting clips attached to the side of the emplacement, so that on firing, the downward shock of discharge comes on the supporting clips, and not on the ram cylinders. Also the shock of discharge in a horizontal direction is transmitted through the guide plates and small trucks to the sides of the emplacement.

These supporting clips fold back into the sides of the emplacement when it is required to lower the gun again. The gun is mounted on the platform on the ordinary pattern of carriage with Vavasseur twin buffers.

The elevating gear is attached to the carriage and consists of the ordinary method of giving elevation and depression by means of a handwheel and a train of wheels. The gear for traversing may be either the usual pattern where there is a toothed rack into which gears a pinion turned by handles and a train of wheels; the rack would be

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fixed to the platform and the gun could be traversed to and fro on it; or else hydraulic power may be utilized to traverse the gun in the following manner:—

A circular iron band which runs round the front segment of the emplacement; it has two grooves cut in the top and bottom, and into these fit two projections. This ring is moved "Trail Right" or "Left," as the case may be, by means of a chain. When the gun is raised to the firing position, the projections fit into grooves in the platform, so that the ring and platform become one, and any movement of the chain moves the platform also.

The ends of the chain are attached to two hydraulic traversing cylinders, and if the command "Trail right" is given, the pressure is applied to the left cylinder, and *vice versa*. In this case of course there is no traversing arc on the platform, but the gun carriage is fixed in one position on the platform. These cylinders are similar to those used for the same purpose in the 100-ton gun emplacements.

Similarly, the ammunition can be lifted and rammed home in the ordinary manner by means of a derrick and hand rammer, or else hydraulic power can be utilized. The ammunition, previous to loading, is placed on a trolly in the shell store. This is then run on rails over a small hydraulic lift which raises to the required height opposite the rammer cylinder in a position for ramming home. The rammer cylinder is then put in motion, and the projectile and charge rammed home. The rammer cylinder is in a horizontal position and rams home when the ammunition lift has brought the projectile and charge to the right height. The rammer cylinder could also be made to perform the sponging out of the bore as well as ramming home, the sponge head being fixed on behind the rammer head. For heavy guns a water jet would be necessary to cleanse the bore each round.

The means of laying the gun would be either by mirror reflecting sights, or else by direct laying, No. 1 standing on the platform while doing so.

If hydraulic pressure were used as a means of working the gun and platform, there would have to be a separate accumulator to get up the requisite pressure. One such accumulator might be made so as to serve several guns in one battery, according to the weight of the guns mounted. A hand pump would not be necessary if an accumulator were used, as the pressure from that could be utilized for raising and lowering the gun. There are many means of storing up the necessary pressure in hydraulic accumulators for use in working the gun.

A steam pump may be used to raise the weight, or a hand pump with long handles, so that several men can be employed at once. Both these methods are employed in the 100-ton gun emplacements. A steam pumping engine being used in the first instance to raise the weight, and a hand pumping gear being ready also, to be employed on an emergency.

Another method, which seems a feasible one, for raising the weight and getting up the necessary pressure in accumulators might be here suggested. It is to employ the rise and fall of the tide on the sea coast. Most heavy batteries are situated either on or quite close to

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the sea shore, and, in the case of batteries at home and most stations abroad (the Mediterranean excepted) there is a considerable rise and fall of tide during the day. This might be utilized to raise the weight of an accumulator as follows:—

The cylinder would be made in the ordinary way, but the weight would be differently constructed, it being made much wider and rendered buoyant with circular iron air cylinders. It would be weighted down so that it only just floated in the water, and would be placed in a circular pit, the water being admitted at ebb tide below it. As the tide rose so would the weight, and when the tide was full, the interior cylinder of the accumulator would also be filled, and on the tide falling, the whole weight, which hitherto had been buoyed up, would press on the head of the cylinder, and cause sufficient pressure for working any batteries close by.

The tide rises in ports at home to a considerable height, from 18 to 30 feet, and a weight raised in the manner indicated would be capable of giving a considerable pressure for the purpose of working hydraulic gear. These accumulators would be close to the shore, and could be protected from the enemy's fire, either by accidents of the ground, or by artificial earthworks, and one such would suffice for the working of whole battery.

With reference to gun platform and gear attached, previously advocated, it may be added that the construction is simple and consists of few parts most of which are under cover, and none of which are easily liable to become damaged or get out of order. The drill would not be difficult, and an ordinary gunner could easily be taught to manipulate the handles and gear.

Another point in favour of this system is that any size and weight of gun can be mounted in this kind of emplacement, an increase in the size of the parts being necessary for an increase in weight of gun.

Some form of disappearing carriage must sooner or later be adopted for coast batteries, as it would be very difficult to work a gun mounted on the present open *barbette* principle in the face of recent improvements in the power and accuracy of guns, and the great development of machine gun fire.

The system now proposed seems to present few difficulties of construction, provides complete cover for the detachments working the gun, and places them entirely out of reach of machine gun and shrapnel fire, and even of vertical fire also. The gun, too, appears over the parapet for a short space of time only, and with a well concealed earthwork would present a very difficult object for an enemy's vessel to aim at.

SAUGOR,

5th August, 1886.

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THE PROTECTION OF HEAVY GUNS FOR COAST DEFENCE.

BY

CAPTAIN G. S. CLARKE, R.E.

THE following paper was originally written in the Autumn of 1883, and was subsequently printed officially. It has since been re-cast and expanded so as to include recent experience.

Questions of coast defence have special importance for England, and, in rightly dealing with them, the co-operation of many minds is needed. The protection of heavy guns is a special branch of fortification in which the views of Artillery Officers should have at least equal weight with those of Engineers. In offering this contribution to the discussion, I do not venture to hope that the opinions put forward will receive universal acceptance. By stating a case, however, and attempting to justify it, something is perhaps gained in clearing away the vagueness which is apt to cloud thought.—*G.S.C.*

LONDON, *December, 1886.*

THE science of coast defence may be defined as that of mounting heavy guns to the best advantage, the latter depending on two sometimes antagonistic conditions:—1st, the offensive power of the gun must have its fullest scope; 2nd, the protection given to the gun and detachment must be the maximum, compatible with the first condition, and with reasonable economy. These are no new principles; yet, in applying these in future, considerable deviations from previous practice may be expected. Great coast forts, such as South Hook, Popton, Hubberstone, Carlisle, and Camden, covering a considerable area, and provided with barrack accommodation of every kind, will be more rare; while interior keeps likely to be the first portion of the works to suffer under fire will certainly be omitted. Future coast defences will, probably, take the form of powerful batteries, either provided with comparatively slight gorge defence, or protected by a field or provisional redoubt commanding their dispersed emplacements. Even in the case of a ring of land defences with flanks resting on the sea, as at Plymouth, it is unlikely that the heavy guns which might be required for the sea defence of those flanks would be placed in the forts themselves, but rather in independent open batteries commanded by them or within

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their protective circle. The reasons for the change are mainly three: 1st, the breech-loading rifle, aided by the machine gun, has rendered comparatively slight earthworks, when supplemented by obstacles, eminently defensible against a ship's landing party; 2nd, the modern war ship has few men to spare, and risky operations ashore are now less likely to be undertaken than formerly, while landing under fire is one of the most formidable of military operations; 3rd, the reduction of depth to a minimum is essential. Coast batteries can rarely be required to stand a land attack of the nature of a siege, and have, in fact, seldom been so designed. A force provided with siege guns would have made short work of South Hook, even when it was new; while the vast ditches of Carlisle and Camden are calculated to resist an attack the possibility of which implies the previous loss of all that these forts are intended to defend. In any case, it will probably be admitted that the gorge of an independent coast battery must either be defended, directly or indirectly, against the attack of a mere landing party unprovided with siege artillery, but possibly disposing of light field guns; or it must be made as strong as the front of a land work. No intermediate measure of protection appears logical. Large and important harbours, whose capture would be worth the risks of a great expedition equipped for operations ashore, must have land defences, permanent or provisional, on which their sea defences would depend.

It may probably be taken, therefore, that the coast battery of the future will, as a rule, have comparatively little permanent gorge defence, and less barrack accommodation. In this there is a simplification of the problem of coast defence, which is much more apparent than real. It is now less a question of pure fortification than of technical detail and the influence of the 'old masters,' which has too long cramped the views of engineers, is now passing away. In the many complications of that detail, yearly increasing with the weight of guns, in the adjustment of the delicate compromise between mutually incompatible advantages, and in the adaptation of works to sites with a view to obtain concealment, there remains an ample field for genius. Moreover, with the increase of range in attack and defence, and the great diversity in draught, armour, armament, and general capabilities of modern vessels of war, there has come increased difficulty in siting coast guns to the best effect. The chart must be studied more carefully, and it is more than ever necessary for the engineer to be able to look at questions of coast defence from the purely naval point of view.

These questions are particularly important at the present moment. After a gradual advance, dating from the introduction of rifled guns, artillery has now taken a decided leap in the introduction of the long breech-loader. The defence of the more important of our coaling stations has already been taken in hand; that of the commercial ports cannot be long delayed; while the time has certainly arrived for a re-armament, combined with revision, or reconstruction, of our fortresses at home and abroad. It will not therefore be out of place to consider the question of the protection of heavy guns in the light of such experience as is forthcoming.

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All methods of protection, existing or proposed, may be divided into three groups:—

1. Complete material protection, limited only by the size of a port, to detachment, and to gun during loading.
2. Varying protection against direct fire. No bomb-proof overhead cover. Detachment more or less protected from machine gun and shrapnel bullets in various ways.
3. Gun completely protected during loading by being lowered.

The following is a brief statement of the advantages and disadvantages of the methods severally included in the above groups. Examples of the practical application of these methods are instanced:—

GROUP 1.

a. *Shielded Casemates.*—Two tiers, Picklecombe, Garrison Point. One tier, (Plate I., Fig. 1) Bovisand; Thames and Medway defences; Hurst Castle; Seaforth; Forts Tigné and Delimara, Malta.

Advantages.	*Disadvantages.*
Complete protection to mounting and detachment against the heaviest projectiles, limited only by the thickness of shield adopted and the size of the port. Complete protection against high-angle fire. Perfect protection against machine gun fire and shrapnel, except at the port.	Effect of a heavy shell near junction of shield and masonry not yet fully ascertained, possibly very great. Hit in crown of arch above shield, possibly disastrous. Hit below sill probably fatal in some existing cases. Cost entails crowding of guns, which is unadvisable in several respects. Merlons liable to be destroyed. Always offers a large target especially in a two-tier work. Liable to cumulative damage at long range. Port usually limits elevation of guns. (At Garrison Point the heaviest guns have the least range). Lateral range of individual guns limited. Field of view restricted for aiming purposes. Difficulties arising from powder smoke.

b. *Curved Front Shielded Casemates.*—King's Bastion, Gibraltar. Sliema Fort, Malta.

Advantages.	*Disadvantages.*
See above. Large field of fire; curved form incidentally unfavourable to penetration, except to nearly direct hits.	*See* above. The port which is not in use is a source of weakness. A single shell entering there would probably disable the gun. Time is lost in traversing from port to port and, consequently, there is difficulty in following a moving object.

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c. *Continuous Iron Front.*—Two tiers, Horse Sand and Noman's Land, Spithead. One tier, Spitbank, Plymouth and Portland Breakwater Forts; Fort Cunningham, Bermuda.

Advantages.	*Disadvantages.*
Complete protection, except at port, against projectiles of all sorts, limited only by thickness of armour adopted. Overhead protection. Closest approximation to a broadside ironclad.	Costly; crowding of guns therefore inevitable. Usually a conspicuous target. Elevation and training limited. Field of view restricted for aiming purposes. If penetrated, it is possible that two guns could be disabled by a single projectile.

d. *Grüson Battery.*—Langlütjensend, German defences on Baltic and North Sea.

Advantages.	*Disadvantages.*
Protection very complete. Curved form favourable to deflection of projectiles. Economy over wrought-iron or compound armour claimed, but possibly not sufficiently established. Requires the occurrence of several hits in a small area to produce much result. Port reduced to a minimum.[1]	Guns necessarily crowded, thus giving to the attack a considerable margin in direction of fire. Individual segments proved to be capable of being broken up by repeated hits. Probably somewhat cramped. Lateral range of individual guns limited. Field of view restricted.

e. *Non-recoil Gun.*—System tried by Krupp in 1877–78 with guns of 15 and 15·5 cm.

Advantages.	*Disadvantages.*
Perfect protection (except to muzzle of gun) limited only by thickness of armour adopted.	Probably inapplicable to heavy guns. A single hit at or near muzzle might jam gun. Whole weight has to be lifted or lowered in aiming. Training limited.

f. *Turret.*—Dover, sole English example; Fort Milutine at Kronstadt.

Advantages.	*Disadvantages.*
Complete protection, limited only by thickness of armour and size of port. Curvature unfavorable to penetration. Relatively small target. All round fire. Two guns combined in one protection. Overhead protection against shrapnel and splinters. Conning tower affords wide field of view for aiming purposes. Proved to work satisfactorily on board ship.	Excessively costly. Steam or hydraulic power required. Possibility of jamming perhaps not yet fully realised. Not well suited to colonial conditions generally. Somewhat conspicuous.

[1] The Grüson system of mounting with a muzzle pivot is probably applicable to any form of turret or cupola, and is a matter altogether apart from the question of chilled cast-iron armour.

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g. *Compound armoured Cupola.*—Lately under experiment at Eastbourne.

Advantages.

See Turret. Conical curvature specially unfavorable to penetration. May possibly be worked by hand power with smaller natures of gun. (Two 9-inch guns of 12 tons constitute the greatest armament which has at present been worked by hand power alone). Lends itself well to dispersion.

Disadvantages.

See Turret. Some difficulty in rapid fine laying may be experienced, if traversing is done by men at a distance. Interior space much cramped. Somewhat conspicuous as a target.

h. *Grüson Turret.*—German defences in the Baltic and North Sea. Defences of Holland. Spezzia.

Advantages.

See Turret. Cast-iron allows any curvature of form. Economy claimed.

Disadvantages.

See Turret. A segment several times hit will break up; the destruction of a segment would seriously affect whole turret.

GROUP 2.

a. *Open Battery with Shields* (Plate I., Fig. 2).—New Tavern Fort. Some Batteries at Gibraltar.

Advantages.

Great front protection, as merlon can have unlimited thickness of earth. No exposed masonry required. Can be rendered fairly inconspicuous.

Disadvantages.

Difficulty in affording adequate support to the shield, since the latter can have only side and bottom abutments, and the top is unsupported. Angle of training limited. Elevation to some extent restricted. No proper overhead cover, since the latter as usually provided, is probably useful against shrapnel and splinters only, and positively adds to the danger from heavy common shell.

b. *Open Battery with Earth Embrasures.*—South Hook, Milford Haven. All the heavy gun batteries at Alexandria except Meks. Defences of Marseilles.

Advantages.

Cheap. Lends itself to dispersion. Can be rendered very inconspicuous as a target. Fair protection against machine gun fire, at least till much of embrasure is destroyed. Protection easily capable of repair. Great flank protection can be given.

Disadvantages.

Embrasure necessarily weak at the neck. If gun is on a low carriage, detachment exposed to shrapnel and machine gun fire after neck is destroyed. Horizontal angle of fire limited.

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c. *Barbettes.*—With bonnettes, Isle of Grain Fort; without bonnettes, Inchkeith, Harding's Fort and Europa Hutment, Gibraltar.

Advantages.	*Disadvantages.*
Angle of fire unlimited unless bonnettes are employed. Lends itself well to dispersion. Can be rendered inconspicuous as a target.	Gun itself necessarily more or less exposed. If not bonnetted, specially exposed on flanks, where it offers a broadside target. In the case of low sites, under-cover loading almost absolutely essential, in order to give protection to detachments against machine gun fire, but very difficult to arrange with larger natures of M. L. guns. In side-loading, there is a considerable expenditure of power in traversing the gun, and when traversed the latter proffers a broadside target.

d. *Light Cupolas.*—Practically a *barbette* mounting on a turntable and provided with shrapnel and machine gun protection. Doubtful if at present existent.

Advantages.	*Disadvantages.*
All round fire. Good protection against shrapnel, splinters, and machine gun fire.	Cupola probably sufficient to catch and burst shell which would otherwise be harmless. Crest protection to glacis equal to that of a turret probably required to lessen risk of jamming. Cramped interior space. Applicable only to B. L. guns. Possible difficulties as to sighting. Untried at present.

e. *Breech Hoods with Barbette Guns.*—No present example. Hoods are being manufactured for naval purposes.

Advantages.	*Disadvantages.*
See *Barbettes.* Good front protection against machine gun fire and shrapnel to loading numbers and breech action. Possibly additional protection against a hit by a heavy projectile at a small angle.	See *Barbettes.* Applicable only to B.L. guns. Possibly somewhat cramped for working. Lateral protection *nil,* unless angle of training is comparatively small target slightly increased. Shell, otherwise harmless, may be burst by the hood. Untried at present for land service.

f. *Barbettes, with turntable and horizontal splinter proof shield. Loading performed at elevation, the breech being depressed through an opening in the shield*—(Plate II.) Adopted for H. M. S. *Collingwood,* &c. No present example in the case of shore guns.

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Advantages.

Excellent protection to loading numbers. Gun offers a small mark during loading. Can be rendered fairly invisible. Protection equal to that of a turret, obtained at much less cost. Comparatively small weight to be moved for traversing. All round fire.

Disadvantages.

Requires power to raise breech into firing position. Muzzle and chase of gun always exposed. Untried at present for land service.

GROUP 3.

a. *Counterweight Carriages.*—Flatholme, Lavernock, Popton, Hubberstone, Newhaven, Carlisle, Camden.

Advantages.

Excellent protection to gun and detachment except to former at moment of firing. Laying performed under cover. Can be rendered absolutely invisible except for the short time the gun is up. Probably highly economical when range of fire and degree of protection are considered.

Disadvantages.

Unsuitable to new long guns. Carriage necessarily somewhat complicated. Weight increases rapidly with that of gun. Possibly inapplicable to larger guns than 10-inch M.L. of 18 tons. Has at present been applied in England to no gun heavier than 9-inch of 12 tons.

b. *Hydro-pneumatic Carriage.*—Constructed at Elswick for 8-inch B.L. guns for Government of Victoria, and successfully tried at Shoeburyness in November, 1885, (Plates III. and A). Shortly to be tried with 9·2-inch and 10-inch B.L. guns.

Advantages.

See Counterweight Carriage. Addition of a horizontal or turtle-back shield confers great overhead protection, except against high-angle fire of heavy shells.

Disadvantages.

Probably requires special care in maintenance. Difficult to repair. At present untried in this country for guns heavier than 8-inch B.L. of 12 tons.

c. *Counterbalanced Disappearing Carriages.*—Fort Constantine at Kronstadt.

Advantages.

See a and b above. Gun can be sunk as low as desired below crest of parapet. Gun can be worked simply *en barbette* if desired.

Disadvantages.

Both gun and platform have to be raised and lowered. Steam essential for rapid firing. Probably costly and somewhat complicated. At present apparently applied to 11-inch B.L. long guns. Not much known about success of working.

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d. *Floating Platform.*—Shortly to be tried with 6-inch B.L. gun at Trow Rock, Tynemouth.

Advantages.	*Disadvantages.*
See above. Cost would probably increase in a low ratio as the weight of gun increased. Gun can be worked simply *en barbette*, if desired.	Very costly in the case of light guns. Probably slow in action. Complete circular pit essential. Difficult to apply over-head splinter-proof shield.

Other methods of protection might have been instanced, but the above may perhaps be accepted as a complete category of types under which all mountings adopted, or likely to come into use, may be classed. It is to be observed that, with one exception, none of the methods of iron protection above enumerated have been subjected to the actual test of war. The shielded casemates, cleverly extemporized during the American war, cannot be taken as fair specimens of their class, nor can the experience gained with the American monitors be considered of value in estimating the effective protection conferred by a modern turret or cupola. The 5½-inch armour of the *Huascar's* turret was, however, hit three times by 9-inch Palliser shell in her action with the *Blanco Encalada* and *Almirante Cochrane*. This turret was twice penetrated, and a shell burst on the deck below without preventing it from revolving. Further, there have been few experiments made under even approximately service conditions, with the exception of those carried out at Shoeburyness against two shielded casemates in 1865, and against two iron-fronted casemates in 1868.[1] Important trials of experimental shields were also made in 1867, 1868, 1869, 1870. Three shots were fired at the turret of the *Royal Sovereign* in 1867, and two shots at the *Glatton's* turret from the *Hotspur* in 1872. The guns employed against the shielded casemates were 10-inch of 12 tons, 9·22-inch of the same weight, 8-inch and 7-inch; against the iron-fronted casemates 12-inch of 25 tons, 10-inch of 18 tons, 15-inch S.B. of 19 tons; against the *Royal Sovereign* 9-inch; and against the *Glatton* 12-inch of 25 tons; so that as indications of what might be effected by the far more powerful guns now afloat, the results of these experiments need much qualification.

The maximum effect of a projectile of given weight, material, and velocity, against a wrought-iron plate, can be predicted with some accuracy. The effect on compound or steel plates is at present less certainly known. Of all methods of protection the continuous iron front perhaps lends itself best to the test of piecemeal experiment. Whether the armour can keep out a given projectile can be ascertained by the experience gained with individual plates, and there remains only some uncertainty as to the effect of a heavy shell striking just at the edge of the port, while the result which could be obtained by a shell after penetration, is more or less a matter of conjecture. All the other cases—masonry and iron casemates, open shielded

[1] *See* a paper by Colonel Inglis, R.E., Professional Papers, Second Series, Vol. XVIII.

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batteries, turrets, cupolas—present certain doubtful features. Any one might chance to receive a hit, the effect of which cannot with certainty be predicted.

On the other hand, earth batteries have been tried over and over again in the past, were hammered with heavy smooth-bores and rifled guns in the American war, and have recently been severely tested at Alexandria under conditions extremely favorable to the attack. With respect to works of this class, therefore, we occupy a somewhat different position, and possess fairly satisfactory data from which to form conclusions.

As to other methods of protection we are still more or less in the dark, and reasoning cannot well be divorced from mere speculation. In some respects it would be extremely useful to make a few practical experiments, and a partial battering of Stack Rock by the *Dreadnought* would be sufficiently instructive to justify the expense; but the great difficulty of keeping the results of such experiments secret in England is unquestionably a strong argument against them.

Passing over the period when the early guns were mounted in castles, such as St. Mawes, Falmouth, and active defence had not begun to assert itself, the earliest form of coast battery was probably a low *barbette*, the guns simply firing over a wall or bank. Examples of such batteries are still scattered round our coasts, and are occasionally used for saluting purposes. The invention and development of shell fire soon tended to produce a higher front protection, and the earth and masonry embrasure arose, the latter usually involving a stone or brick fort. The fort trying to compete with the ship in volume of fire would sometimes have two, three, or four tiers. The Spithead forts were originally designed for four tiers, and were also intended to mount guns on the top, while there is an existing three-tier stone work at Kronstadt.[1] Great crowding of guns thus arose. The development of penetrative power which the rifled gun attained, led naturally to the adoption of iron shields, and works of the Bovisand, Popton, Hubberstone, Hoo and Darnet type were constructed, the double tier being retained in some cases, as at Picklecombe and Garrison Point. The desire to imitate the ship further, gaining still greater protection and this of a more uniform nature, produced the continuous fronts at Spithead, Plymouth, and Portland. Finally, still following the ship, a cramped advanced site, exceptionally heavy guns, and the desire to realize the most complete protection possible combined with an all round fire, produced the Dover Turret. Meanwhile, however, the expense and other disadvantages of the stone and iron method naturally directed attention to alternative modes of protection. As early as 1835, Colonel de Russy of the U. S. Army, invented a carriage in which the gun was rolled to the rear on eccentric wheels and lowered. In 1868, Major King, U. S. Engineers, invented a counterpoise carriage which was successfully tried with a 15-inch gun firing a 450 lb. projectile with 100 lb. charge. About 1871, Colonel Moncrieff

[1] The Russians appear to have been the greatest exponents of this system, and the Sebastopol works probably exercised a definite influence over our own later coast defences.

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also reduced the disappearing principle to a practical shape, and succeeded, in 1873, in overcoming great difficulties with rare energy and mechanical genius. In spite of the highly favourable report on the counterweight carriage for the 9-inch gun of 12 tons, this mounting can hardly be said to have been introduced into the service—there are only two existing examples[1]—and practically the principle is restricted to guns not heavier than the 7-inch of 7 tons. The best example of the application of this principle is at Flatholme, where the emplacements are fairly dispersed, and well concealed. These emplacements are, as far as protection is concerned, quite as satisfactory as when they were first built. The worst instances are at Popton and Hubberstone, where the pits are built up in a row on the top of stone and iron casemates, and at Newhaven where one of the 9-inch guns is mounted in a species of demi-Martello tower. The rapidly increasing cost of the mounting in the case of larger guns led Colonel Moncrieff to the design of hydro-pneumatic carriages, which are represented in principle by the hydro-pneumatic siege-carriage of to-day, the disappearing mounting for the 8-inch B.L. gun[2] (Plates III. and A) successfully tried at Shoeburyness in November 1885, and the new mountings for the 9·2-inch and 10-inch B. L. guns now under construction.

Up to a certain point, therefore, the maximum possible of material protection was the object aimed at in gun mounting. At the same time the great cost of invulnerability rendered other modes of protection necessary under a variety of circumstances, and open batteries and *barbettes* have not only never altogether disappeared, but have been largely constructed. The French have so far steadily abstained from constructing armoured casemated batteries for coast defence. For fairly elevated sites, the *barbette* mounting, on account of relative cheapness, wide angle of fire, and unlimited facilities for elevation, has always found favour, and the application of this principle in all[3] the French battle ships and armoured cruisers, in the *Italia*, *Lepanto* and three subsequent ironclads, as well as in our *Impérieuse*, *Warspite* and *Collingwood* certainly points to this method of mounting as little likely to be abandoned in the future. In the *Téméraire*, England took the lead in applying the disappearing principle to a ship of war. Meanwhile, however, the great development of shrapnel and machine gun fire has tended to increase the minimum of height above the sea level prescribed for *barbettes*, to add to the height of front parapet, and to bring methods of under-cover loading into prominence. The heaviest English guns at present mounted—the 100-ton R.M.L. at Gibraltar and Malta—are in *barbettes*, fire over a high parapet, and have a complete system of under-cover loading, so that practically the gun alone is exposed to direct fire.

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[1] At Newhaven.

[2] In Plate III., the gun is shown in the loading position. In Plate A, the gun is loaded and partially raised, remaining invisible but ready to be quickly run up and fired.

[3] The eight turret vessels of the French Navy are classed as "Coast Defence" ships. In the Italian Navy, the *Duilio* and *Dandolo* are the only turret ships.

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The general adoption of the breech-loading system is now an accepted necessity for heavy guns. It is a necessity brought about by the demand for length of bore, and is practically one of the direct results of the great advance in the manufacture of gunpowder. Breech-loading, originally condemned on the grounds of complication, is now virtually the simpler system in the case of the larger guns; since the difficulty of providing an altogether satisfactory under-cover loading arrangement for long muzzle-loaders will hardly be overcome. It is doubtful whether any better system can be devised than the so-called "protected *barbette*" applied to 10-inch R.M.L. guns in New South Wales, as well as to the only two long M.L. guns[1] which will ever be built; but the inherent objections to this system are sufficiently apparent. Although no more heavy R.M.L. guns will now be built, the great number in the service cannot be expended, and the time at which all these guns will have been eliminated certainly does not fall within the range of necessary prevision. It may even be contended that under certain circumstances the muzzle-loader is the most suitable weapon, and although it is impossible to admit that the handling of the breech-loader is beyond the powers of local or coloured troops, it may nevertheless prove, that in certain distant tropical stations the new B.L. guns require an amount of care and attention to ensure efficiency, which they cannot with certainty receive. Moreover, there will be a gradual withdrawal from the Navy of R.M.L. guns which, if they are polygroved and mounted so as to elevate up to 15°, will be sufficiently powerful to warrant their adoption for land service in many cases where very accurate long range fire is not required.

Looking to the future, it seems clear that the number of possible methods of mounting may be somewhat reduced. After the results of the experiments carried out at Shoeburyness in May and September, 1884, it is certain that stone and iron casemates of the form shown in Plate I., Fig. 1,[2] will not again be built. If existing structures of this class were remodelled, the overhanging mass at A would probably be dispensed with, and the thickness of masonry at *b* increased so as to provide greater resistance than the shield itself. Open shielded batteries (Plate I., Fig. 2) are certainly obsolete; since it is tolerably clear that a heavy shell striking, as shown, would bring down the "over-head cover" on the gun, and that, in the absence of this protecting mass, such a shell might be harmless.[3] The Moncreiff counterweight principle does not readily lend itself to long breech-

[1] 10·4-inch M.L. proposed to be mounted at Gibraltar.

[2] Taken from a paper by Lieut. (now Major) T. English, R.E., R. U. S. Institution, 31st March, 1873.

[3] With regard to this system, Lieut. (now Major) T. English, R. E., remarked (R. U. S. Institution, 31st March, 1873), "The protection of these so-called open battery shields is quite as good, when in good order, against a short bombardment, as that afforded by a casemate." By "a short bombardment," it is presumed was meant a bombardment in which the 45° concrete slope would not be struck. The heaviest gun at this time was the 35-ton R.M.L., first fired two years previously. The 38-ton gun was tried in the following year.

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loaders. Compound armour is at last becoming discredited. The protection of new heavy guns in coast defences tends, apparently, to reduce itself to the continuous wrought-iron, or perhaps, steel front, Grüson batteries, turrets, cupolas, *barbettes* of some form, or open batteries with earth embrasures. Under exceptional circumstances, such as the very high sites available at Gibraltar, guns may be mounted in the open. The above being premised, it becomes exceedingly important to consider which of these systems will be best under given conditions.

The general problem is somewhat complex, and may be stated as follows:—The maximum present power, offensive and defensive, of the attack may be assumed as known. This power, in the immediate future, may be dimly foreseen. The geographical position of a port with respect to an enemy's possible base of operations, materially affects the scale of necessary defence. Considerations, more or less speculative, indicate the minimum number and powers the shore guns should possess. Economical considerations, more or less inexorable, tend to reduce that minimum. A study of the chart shows the water over which the fire must be distributed. How are shore guns to be sited, and how protected so as to give the maximum offensive power combined with the minimum of vulnerability?

There are here a sufficient number of unknown factors. Relative, vulnerability is excessively difficult to determine, and is, to some extent, a matter of pure conjecture. Moreover, vulnerability, in itself dubious, has to be balanced against offensive power, also in many aspects a matter of debate. The possibilities of the future must not be left out of account, nor can local considerations be altogether neglected. At a station far beyond the reach of telegraph—Diego-Garcia for example—where the advent of a roving squadron would perhaps be the first announcement of the outbreak of hostilities, it will evidently be necessary so to mount guns that they are sure to be available at the shortest notice, and a steam-driven turret would, therefore, be clearly unsuitable. The complication of the problem is, however, not fully stated yet. Submarine mines have grown up as an adjunct—almost an excrescence—of harbour and river defence. Their proper relative position in a scheme of defence has never been assigned, perhaps cannot be assigned. Opinion has differed considerably as to their value. It might now, however, be argued with much force[1] that, granting time for laying them out, mines alone would in some cases permit a reduction of heavy gun power, while in others they would safely allow its modification. But in addition to fixed mines, fast torpedo boats constitute a factor of which the attack must certainly take account, while locomotive torpedoes are emerging from their infancy, and submarine boats have almost passed the experimental stage. With what relative importance shall we credit mine and torpedo defence?

[1] The German ports enjoyed complete immunity in 1870–71, and 16 mines appear to have effectually kept the French out of the Tamsui river in October, 1884, although a week was spent in looking at them.

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Were expense a matter of indifference, a continuous armoured front, or a Grüson battery, for guns needing only a small angle of training, and a turret or cupola for all-round fire might seem to leave nothing to be desired. In the first place, however, it is not certain how much protection of this class we shall have to provide. The next ten years will, doubtless, see guns weighing nearly 200 tons afloat, and future improvements in powder and projectiles may give these guns much greater penetrative and destructive power than could now be obtained with the same weight. It is in the direction of greater penetrative power (*i.e.*, of offensive power against protection of this class), that gun progress is obviously moving. To oppose to the ship shore defences as closely as possible resembling herself, is in one sense to favour the attack, since the same guns and projectiles which the ship *must* carry, in view of a naval action, will be precisely the kind best suited for dealing with such shore defences. It is clear that we cannot build such batteries every ten years on our more important first line sites, and it would probably be difficult to strengthen a Grüson battery subsequently and not very easy to strengthen a turret or cupola. What measure of strength shall we decide upon? Moreover, to limit the range of our guns in future by the size of a port is not to be thought of; small ports and muzzle pivoting become inevitable, nearly the whole weight of the gun must be lifted or lowered in laying, and steam or hydraulic power soon becomes necessary. With a turret or cupola, the necessity for driving power is still sooner reached. It is doubtful if even a 38-ton gun could be worked by hand power in a cupola. There is, perhaps, no real objection to following the example set in the modern ship of war. But to do so clearly introduces a new set of risks, inevitable for the ship, but which should be avoided in the shore battery as long as possible. As long as a gun can possibly be worked by hand, there is evidently an argument against further complications of any kind. Turret and cupola alike must be full of machinery, which a single man who chanced, temporarily, to lose his head might damage beyond the possibility of immediate repair. Moreover, there must be a risk of jamming either turret or cupola by a lucky shot, for although the *Hotspur* failed against the *Glatton's* turret in the round fired with this object, the vagaries of a fired projectile, with the high velocities now attainable, defy calculation, and it would be unwise to assume complete immunity from this risk on the grounds of a single experiment.[1] It would hardly have been expected

[1] On this question Colonel Inglis pertinently remarks, referring to one round fired at a turret target at Shoeburyness—"The projectile, which struck close to the bottom of the target, turned in the direction in which it felt least resistance, and passed vertically down into the earth. It is probable that a similar result, which would threaten fatal injury to a turret, was just avoided in this trial (that of the *Glatton*) by the graze on the glacis giving the shot such direction as disinclined it to turn downwards on entering the armour." . . . . "To have made the experiment at all complete, the turret ought to have received a shot directed at a point on its side some few feet away from the centre as viewed from the gun." Until this and other points "have been more thoroughly tried, it cannot be said that our information on the subject of either land or ships' turrets is as complete as it ought to be." (R.E. Corps Papers, Vol. XXI., 1873). It is to feared that our knowledge on these points is still decidedly imperfect. It is perhaps worth noticing that Mr. Anderson, C.E., stated (R. U. S. Institution, 25th April, 1884), "My belief is that the turret (Dover) would be so damaged by a single 16-inch shell, that it would be impossible to work it any more." "The energy of one of the bolts of the *Inflexible* striking, say, at 2000 yards range, would be represented by the whole of the Dover turret, which weighs 750 tons, rising 16 feet into the air. Is it conceivable that no derangement would result from such a blow?"

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that a 10-inch Palliser shell striking the unarmoured portion of the *Inflexible* at Alexandria, would turn straight up and pass out through the deck. Further, there would, especially at distant foreign stations, be a certain amount of danger of these elaborate fighting machines being found wanting at the critical moment from carelessness, ignorance, or neglect. A turret or any gun worked by steam power must, practically, be always in commission, and cannot come home periodically for repairs and inspection like an *Inflexible*. Again, if defences of this class are to be adopted on a large scale there must be a considerable increase in the number of Inspectors of Machinery as well as in the force of artificers.

Practically, however, expense is anything but a matter of indifference, and although Italy has adopted Grüson turrets on a limited scale, it will probably be some time before we accept similar measures. Nor does it appear to be certain that they are necessary, or even desirable. The whole question of the choice of modes of protection will be found, on consideration, to be closely bound up with the views which may be taken as to—

1. The probable accuracy of the fire of ships.
2. The probable effect of shrapnel and common shell.
3. The probable effect of the fire of machine and quick-firing guns.

In adopting the *barbette*, open battery with embrasures, or the disappearing principle, certain risks are obviously accepted. Is it worth while for the sake of some great advantages to accept these risks? To this very important question different answers will doubtless be forthcoming, since few will agree on the measure of the risk, and the three points abovementioned, admit—even court—much speculation. If a ship can, at frequent intervals, hit a *barbette* gun, or plant a shell fairly in the neck of an embrasure at moderate ranges; if every heavy shell which strikes near the exterior crest of a parapet will plough its way through, and burst in the battery, *barbettes* and embrasures stand condemned. If the ship can drop the bullets of heavy shrapnel at a considerable angle of descent over the crest of a battery, overhead cover of some sort is universally indispensable. If she can, with reasonable certainty, throw common shell which, striking a little short of the crest at a descending angle, blow in the retaining wall on the gun and detachment, iron protection in some form would seem to be inevitable. If, guided by a momentarily defined smoke-puff, she is easily able to land shells on an invisible target, the range of which cannot be exactly ascertained, the disappearing principle becomes questionable. Finally, if the ship cannot do these things now, is there any reasonable probability that she will shortly be able to do so? Here is evidently a wide field for speculation. The record of ship's practice cannot be kept like a rifle-shooting register. Experimental firing against targets representing shore batteries is excessively rare. We have practically only the experience of Alexandria on which to build, and the easy victory obtained by the ships, makes it all the less likely that the lessons of the action will ever receive serious attention.

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There are some essential differences between a naval attack on shore defences now and at the time of Algiers. Then the vessel enormously outmatched the shore batteries. A first rate ship, with 66 guns to her broadside, was superior to almost any single battery. A fleet was immensely superior to a fortress. Where the shore works were open, the ships could pour in an almost continuous hail of shot and shell. There was room for plenty of bad shooting, and yet there would be plenty of hitting, while the continuity of fire was demoralizing in the extreme.[1] Even in much later days the United States Fleet poured 45,000 shot and shell into Fort Fisher in two successive bombardments, the rate of fire on the first occasion being given as 115 projectiles per minute. It is not surprising that the return fire was very ineffective, and soon practically ceased. In the days of wooden ships the ranges were comparatively short.[2] At Acre, the ships were quietly allowed to take up their assigned stations at from 600 to 700 yards from the defences "before a shot was fired from the garrison." This was an advantage, inasmuch as the details of the work attacked could be well made out, the damage being inflicted was better seen, and the fire could be better directed. Moreover, mines and fast torpedo boats were non-existent and, if a ship could be laid alongside a shore battery—a course our naval commanders always strove to adopt[3]—she could crush the latter by sheer superiority of metal and rapidity of fire.

Conditions are now completely changed. The single ship will rarely outmatch the modern first line battery. The fortress will far more nearly approach the fleet in weight of metal. Thus, the *Dupérré* carries only four 46-ton guns in her *barbettes*, and 14 broadside 5½-inch guns. The *Inflexible* has but four 80-ton guns and eight 20-prs. It is doubtful if these two ships together would be a match for the six turrets of Fort Milutine at Kronstadt. The whole fleet engaged at Alexandria opposed 80 heavy guns to 36 on shore; but, on the one hand, the shore guns could not all be simultaneously employed, while, on the other hand, the actual gun power of the broadside iron-clads must be halved. Compare the broadsides of the *Inflexible* and an old three-decker. With four 80-ton guns and four 20-prs., the former ship can deliver 6,880 lb. of iron at a single discharge. With 48

[1] Even thus the ships did not invariably show a marked superiority over coast works unless the ranges were short. Such facts as the following are not without significance at the present day. In July, 1806, Sir Sidney Smith, "with the *Pompée*, an 80-gun ship, the *Hydra*, Captain Munday, and another frigate, anchored about 800 yards from a battery of two guns, situated on the extremity of Cape Licosa, and protected from assault by a tower in which were 25 French soldiers." "The line of battle ship and the frigate fired successive broadsides till their ammunition was nearly expended, the battery continually replying with slow but destructive effect. The *Pompée*, at which ship alone it directed its fire, had about 40 shot in her hull; her mizen topmast carried away; a Lieutenant (Slessor), a midshipman, and 5 men killed, and 30 men wounded. At length, force proving ineffectual, negotiation was resorted to, and after some hours' parley, the officer . . . . capitulated. It then appeared that the carriage of one of the two guns had failed on the second shot, and the gun had subsequently been fired lying on the sill of the embrasure, so that in fact the attack of an 80-gun ship and two frigates had been resisted by a single piece of ordnance."—*Journal of Sieges in Spain, Major General Sir J. Jones, R.E.*

[2] At Copenhagen it was a matter of complaint that the pilots would not accept the responsibility of taking the ships nearer than 400 yards.

[3] At Algiers, the *Queen Charlotte*, bearing Lord Exmouth's flag, was brought within 60 yards of the mole.

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32-prs., 17 – 8-inch guns, and one 68-pr., the latter delivered 2,556 lb. The 80-ton guns take five minutes to load, and the 20-prs. perhaps half-a-minute, the broadside of smooth-bores about one minute. Thus in five minutes the *Inflexible* fires 7,600 lbs. of iron, the wooden ship 12,780. The total *number* of projectiles in this time is for the *Inflexible*, 44, and for the wooden ship 330. Dealt with in this way figures are not, perhaps, particularly valuable, and the above estimate is highly favourable to the *Inflexible*, since the 20-pr. of to-day posseses much less relative value than the old 32-pr., and would have little chance of disabling a properly mounted heavy gun, while the *Inflexible's* 20-prs. could not be served in face of moderately accurate shrapnel or machine gun fire from the shore. Omitting them, the proportionate rate of fire between the two ships is as 1 : 82·5.[1] In any case, the importance of individual rounds is now enormously increased; but it may fairly be doubted whether the possible destructive effect of a single projectile on well designed works has been materially augmented. It is conceivable that a single lucky 8-inch spherical shell might have dismounted a single shore gun and killed or wounded all its detachment. A 16-inch rifle shell can do no more in a properly traversed battery, may even effect less, since a modern gun and its carriage is a very substantial traverse against splinters, while it is open to question whether a line of battle ship, engaged at 500 or 600 yards, had not actually a better chance of obtaining such a hit than an *Inflexible* at 2,000 yards. Comparing gun with gun, the accuracy of fire has immensely increased. Comparing ship with ship, the chances of hitting have probably diminished, notwithstanding that naval gunnery has greatly improved in the last 30 years. The ranges at Alexandria were somewhat long—less than half those adopted by the French at Sfax however—but it is not certain that ships will gain a balance of advantage in future by closing with good shore batteries properly manned. They will, it is true, be able to bring their machine guns into action; but the effect of the latter will be neutralized in the case of B.L. guns, by the protection which can be provided, and by better protected machine and quick-firing guns on shore. If the shore batteries consist of well designed and dispersed *barbettes*, with good cover for the detachments, the effect of the fire of the ship will in some respects actually diminish as she reduces her range. Shrapnel will become useless. The disadvantage of the ship will be the more pronounced as the elevation of site of the battery increases. Her one considerable advantage is that being nearer, she has a better chance of picking out and inflicting a direct hit on the shore guns themselves. But a shore gun offers a very small front target, and if the guns support one another well, the ship will not always be able to get a broadside shot at one *barbette* gun without laying herself open to the close unreturned fire of another. The comparative targets of the single ship and single gun is enormously against the former, and if there is sufficient dispersion, it is clear that it is this

[1] Captain Fisher, R.N., basing his calculations on tonnage, and omitting the 20-prs., arrives at the conclusion that it is now necessary to be 620 times as good a shot with the *Inflexible's* guns as with those of a line of battle ship; or, in other words, that a miss is enhanced by this number as a multiplier.

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comparison which must be instituted and not that of the ship and battery. Practically, however, the ship will in many cases have little option in the matter of range, on account of submarine mines and the action of fast torpedo boats; while, in most cases, it is possible for the designer of the shore battery to fix the minimum range at which a vessel of given type can engage it. If the tactics adopted by the French at Sfax—boats at "a few hundred yards," gun-vessels at about 2,300 yards, ironclads at 7000 to 4,300 yards—were tried against well-armed and well-fought shore batteries, the policy of the latter would be evident. First dispose of the boats with machine gun fire and case, then sink the gun-vessels with common shell, treating them simultaneously with shrapnel, finally commence deliberate fire with armour-piercing projectiles and common shell on the ironclads. The three operations can be successively carried on with considerable security. It will need a great deal of shooting from the gun-vessels before a shore gun is grazed, and the ironclads will do no harm at all to the defences. At Sfax, after a remarkably deliberate fire of 2,002 projectiles delivered under peace practice conditions, the "defensive power" of the place is reported to have been "practically uninjured."

Some facts drawn from the Alexandria action throw a strong light on the question of the accuracy of fire to be expected from ships. Meks Fort, a pre-historic work, armed with five heavy R.M.L. guns, nine S.B. guns, and five mortars, was engaged by the *Monarch*, *Penelope*, *Invincible*, and *Téméraire* for about three and a half hours. During one hour the *Inflexible* contributed a portion of her fire. The ranges of the three first-named ships varied from about 1,200 to 1,000 yards, that of the *Téméraire* was 3,500, and of the *Inflexible* 3,800 yards. The *Invincible* and *Téméraire* were anchored throughout the affair. The guns of Fort Meks were practically all *en barbette*, the three heaviest of them firing over a 4-feet 8-inch parapet, the interior wall of which projected 1 foot 10 inches above it, with a thickness of 2 feet 6 inches. During the action not a single gun was dismounted or disabled, and two only were touched by heavy projectiles which just grazed them, leaving indents 1¼-inch deep. One gun was knocked over by an 8-inch Palliser shell from the *Penelope*, fired at short range after the work was silenced; when, therefore, there was no return fire, and no smoke enveloping the battery. The two grazes may of course have been similarly obtained. Altogether about 580 heavy and 340 light projectiles were fired at Fort Meks. Theoretically, of course, this work should have been silenced in ten minutes by the machine guns of the in-shore squadron alone. That Fort Meks was able to reply for more than twice three hours to the overwhelming fire poured into it, clearly shows that low level *barbette* batteries, if properly built, can well be fought. If this particular work had been constructed in accordance with the most elementary principles of defence; if the gunners had been able to handle the R. M. L. gun as well as they did the smooth-bores;[1] and if the armament had been supplemented by a few machine

[1] The *Invincible* was hulled 15 times and the *Penelope* 8, in addition to receiving a round shot in one of her ports.

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and quick-firing guns on the flanks, and in Fort Namusia above, the ships would have been defeated without any difficulty.

Again, the *Inflexible*, at about 3,500 yards, partly at anchor and partly under weigh, engaged two "most troublesome" 8-inch guns in Oom-Kabebé for about four and a half hours. She was simultaneously engaged with Fort Ras-el-Tin. The two Egyptian guns fired over 4-feet 3-inch sills in a straight parapet 5 feet 6 inches high, and were about 36 feet apart without any intervening traverse. The whole sea-front parapet of the work was hit nine times, the top of the counter-scarp or glacis three times. The extreme hits were 120 yards apart. The face containing the two 8-inch guns was hit four times, three hits occurring on the superior slope, and one on the cordon of the scarp. The three hits on the superior slope made large craters, the shells bursting well. One of them blew in the revetment wall between the guns for a length of 12 feet and a height of 3 feet. Neither gun was touched except by masonry splinters. If these guns had been 10-inch, manned by English gunners, and the *Inflexible* an unarmoured cruiser, the latter would doubtless have been sunk or disabled; while the unarmoured ends of the *Inflexible* herself would have suffered severely. The cost of mounting these guns, including the thickening of the old parapet, may have reached £100. In the whole action, in spite of the many advantages on the sides of the ships, the total number of hits on the parapets of all the works—*i.e.*, on the superior and exterior slopes—was about 1 in 19 rounds, excluding shrapnel and segment. Considering that a large proportion of these hits were on exterior slopes, and were practically thrown away, while the average was certainly improved by some short range practice after the works were silenced, the risk of a direct hit incurred by a *barbette* gun certainly does not appear to be excessive at moderately long ranges. In many respects the action at Alexandria supplies a wholesome corrective to views based mainly on too wide a generalization from unsuitable data. Thus, there can be little doubt that far too much accuracy has been expected from the fire of modern ships of war, and that the expectation has been derived from practice at Shoeburyness, and from the results obtained in experiments with siege guns. It would not have been impossible to carry out a series of experiments in which ships should fire at extemporized shore batteries under conditions as far as possible assimilated to those of service, the results being carefully noted; but such experiments were wanting, and exaggerated expectations were inevitable. Another generally accepted deduction from the Alexandria affair, and one extremely important to the defence, is that it is useless for ships to engage earth batteries by circling in front of them. It is necessary either to anchor or steam up to a buoy to fire, and the elliptic courses which theory delights to prescribe must be utterly given up where coast defences cease to proffer a target.

Turning to the question of the employment of common shell against earthworks, Alexandria also affords subject for reflection. Probably the most destructive result which can be obtained by a common shell is a hit delivered with a descending angle a little short of the crest of a

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battery, blowing it in on the gun and detachment, thus practically adding a shrapnel effect to that of common shell. At Alexandria altogether 11 such hits were obtained out of 1620 rounds, 7-inch and upwards; but many of these did not occur in front, or nearly in front, of guns, and in a well traversed battery would have been quite ineffective. With proper dispersion of guns—even without dispersion, if the batteries are well traversed—the chances of such a hit are simply insignificant, even at moderate ranges. Where the guns have a good command, such a hit can—as will be noticed hereafter—only be obtained at very long range. Moreover, the employment of iron glacis plates in front of *barbette* guns would give complete protection to the crest. Very effective results against men are obtained by a shell which, with a descending angle (the larger the better), just skims the crest and bursts on it or a few feet in rear. Are the risks of such a hit excessive? Large descending angles mean extreme ranges. If a time fuze is used, the accuracy required is measured in hundredths of a second. If a percussion fuze is used it must be delicate and instantaneous, with a view of bursting on the crest, in which case it will be perfectly useless for purposes of weakening a parapet. If it does not graze the crest, it will, with all ordinary angles of descent, burst on the ground beyond too far away to produce any serious loss. This, of course, presupposes that the emplacement is open to the rear, as it should be wherever possible. A common shell just clearing the crest of a circular pit[1] would catch the wall beyond and burst, probably killing every man of the gun detachment, and unquestionably so blocking the emplacement that it might take hours to clear the gun platform. In numerous existing cases guns are mounted close in front of walls admirably placed for increasing the dangerous target.

Again, to burst a common shell in the air in front of an earth battery with embrasures, or a *barbette* with a high parapet, is practically useless. This was fully recognised in Admiral Porter's orders before the attack on Fort Fisher:—"All firing against earthworks when the shell bursts in the air is thrown away" . . . . "A shell now and then exploding over a gun *en barbette*, may have a good effect, but there is nothing like lodging a shell before it explodes." It is doubtless an excellent thing to burst a shell directly over a gun, but it would be interesting to know how many a ship would have to fire before obtaining such a result. Some idea of the difficulty of obtaining much searching effect with common shell from ships' guns is conveyed by the fact that at 2,400 yards the 8-inch howitzer, our best high-angle weapon, under perfectly favourable conditions, gave two effective hits in 20 rounds.

Tables of penetration into earth and sand have found their way into various text books with no words of qualification. It is hardly too much to assert that they are totally misleading. Whatever may be the penetration attained in specially constructed butts, or arrived at by calculation open to objection, it is now sufficiently established that

[1] At Inchkeith, the back wall is actually heightened on the very centre line of the emplacement.

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parapets of earth or sand with exterior slopes will not hold projectiles so as to enable them to penetrate properly. At Alexandria the penetrations, judged from a very large number of examples, were extremely slight. The shells turned up at once and either ricochetted high over the works or were stopped and lay on the superior slope, base to the front. A 16-inch shell from the *Inflexible*, fired at under 2000 yards range, was thus stopped after penetrating less than 20 feet of sand. As might be expected, this tendency to be immediately deflected is still more marked in the case of the new B.L. guns. At Eastbourne an 8-inch B.L. Palliser shell fired at 1193 yards gave a penetration of only 6 feet into a loam parapet with an exterior slope 1 in 2. At Lydd the effect of three 9·2-inch B.L. Palliser shells, fired at 1200 yards against a similar parapet was almost *nil*.

It may probably be laid down, therefore, as an axiom, that the fire of a ship is altogether unable to breach or seriously damage a properly constructed parapet; that exaggerated estimates of penetration must be modified, and that in works not liable to a land siege nothing is gained beyond a certain point by adding earth protection. The Eastbourne experiments further go to prove that shells bursting on a superior slope and causing craters which do not extend to the crest, can effect no damage whatever in an emplacement.

The question of shrapnel is, perhaps, even more important, since shrapnel is to some minds a species of bugbear. The real effect of the 417 shrapnel and segment fired at Alexandria is somewhat difficult to estimate. Only information from the Egyptian side could clear up the point. One gun and carriage received 49 shrapnel bullet hits, all apparently inflicted by a single 11-inch shell from the *Téméraire*, the head and base of which were picked up in front. This gun fired through an embrasure, the neck of which had been previously ruined by the fire of the *Inflexible*. Moreover, it is probable that the hit was delivered the day after the action. The remaining shrapnel hits on guns and carriages might be counted on the fingers, but it is of course possible that very oblique grazes might not have left a distinguishable mark. Some of the naval officers engaged at Alexandria were impressed by the good results of their shrapnel fire, but these results would be considerably enhanced by the defects of the Egyptian works. In estimating the Alexandria results, it is particularly necessary to separate those which the shortcomings of the works rendered inevitable. The fact that a ship could silence the fire of the saluting battery on the line wall at Gibraltar with shrapnel would not be a convincing argument of the efficiency of the latter against coast defences generally. At Meks—a work almost *á fleur d'eau*—there was hardly a place where the head of an ordinarily tall man would be covered if he stood close to the parapet.

The Inchkeith experiments, carried out in August 1884, throw a certain light on the performance of shrapnel at Alexandria. In all, 30 rounds were fired from the 10-inch R.M.L. guns at ranges varying from 850 to 3,500 yards, the average being about 2,330 yards. The conditions so far as the ship was concerned were ideal. The sea was calm; the ranges could be obtained with great nicety; the firing was

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by single rounds and excessively deliberate; undivided attention could be given to each round; there were no elements of disturbance; the Inchkeith gun presented an excellent target. On the first day, out of 15 rounds fired with battering charges, one ball found its way into the emplacement. On the next day full charges were used and two good bursts were obtained in 15 rounds. Four dummies were hit; six balls struck the gun, six balls and three splinters the carriage and platform. In addition, one of the elevating wheels was broken and the traversing gear placed at the rear of the platform was disabled by splinters. The gun could still have been worked.

The spread of shrapnel bullets from heavy R.M.L. guns has not been experimentally ascertained. For present purposes, therefore, it is assumed to follow the same law as that enunciated in the case of field guns by Lieut.-Colonel Nicholson, R.A.[1] Taking the lateral velocity as constant and equal to 90 f.s.,[2] the semi-angle of spread calculated as $\tan \frac{-1\,90}{v}$, where v is the velocity of the shell at the moment of burst, agrees in the case of the 64-pr. exactly with the result actually obtained at Dungeness. In the case of the 10-inch R.M.L., the spread similarly calculated varies from $3\frac{3}{4}°$ at the muzzle to $5\frac{1}{4}°$ at 4000 yards. With this gun, therefore, in estimating the searching effect of shrapnel, it will probably be sufficiently accurate to add 5 degrees to the angle of descent, unless the shell is burst so far short of the object that the increased curvature of the trajectories of the bullets becomes of practical importance. In the case of some new B.L. guns, the angle of opening of shrapnel has been experimentally determined, and found to be as follows:—

Gun.	Range. yds.	Semi-angle of opening. ° ′
12-inch B.L. Mark I.	2000	4 34
	3000	4 40
9·2-inch B.L. Mark III ...	1665	5 0
4-inch	1100	5 10
	2000	5 50
	3000	7 0

The possible searching effect will of course vary much with the height of the shore gun, and the appended diagrams, drawn up by Captain T. S. Jackson, R.N., are extremely valuable in enabling a correct estimate to be formed of the great importance of height in regard to the possible effect of common shell, shrapnel, and machine gun fire from a ship. Thus with the service 10-inch M.L., (Diagram I.) using the 70 lb. charge, a ship must be at 1,750 yards distance to obtain a horizontal trajectory at the crest of a battery 300 feet high, while to obtain an angle of descent of 6 degrees she must move to 3,350 yards. If the crest of the battery is 100 feet high, the

[1] "Shrapnel Fire."

[2] Calculated by Captain T. S. Jackson, R.N.

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corresponding ranges are 1,050 and 2,950 yards. A common shell arriving at an emplacement with a horizontal trajectory, can do little injury to the revetment wall. Striking only a few feet short of the crest, it will be deflected up, unless the burst is instantaneous, in which case (as proved at Eastbourne) the splinters all clear the emplacement. Practically, therefore, to be really dangerous, the shell must burst *exactly at* the crest, which means hitting a target a few inches high, as well as securing an instantaneous burst. Supposing a 10-inch R.M.L shrapnel to be burst in the most favourable position possible, the bullets, in the case of a crest 100 feet above the ship's guns, will at 1000 yards have a drop of less than 11 degrees, and at 16 feet from an 8-feet parapet would be still 5 feet above the ground level. A just appreciation of the above facts will render apparent the difficulties under which the ship labours in delivering a searching fire, and perhaps serves to explain why the French ships do not carry shrapnel for heavy guns. These difficulties will be materially increased by the introduction of guns giving higher velocities. For example, the height of the new emplacements for B.L. guns on Stone Cutters Island, Hong Kong, is about 210 feet. At this level, projectiles from the French 27^{cm} gun (Diagram 2) with a muzzle velocity of 1664 f.s. will have a horizontal trajectory at 1750 yards, and a fall of 6°, or 1 in 9·7 only at 4000 yards. In the case of a higher-powered gun, snch as our 9·2-inch, Mark III., with a muzzle velocity of 2065 f.s., the corresponding ranges would be about 2100 and 4800 yards. The searching power of the fire of modern ships is, therefore, strictly limited, and the difficulty of killing men behind a high parapet by shrapnel fire from high velocity guns has, perhaps, been insufficiently appreciated; while the danger to the revetment in front of a *barbette* gun, or to the crest of a pit cannot be regarded as serious.[1] As regards searching effect, ships are now in a worse position than they were 50 years ago, and when re-armed with new guns their power will in this respect be still further diminished.

It has been suggested that, in view of the difficulty above pointed out, a complete or partial return to short guns and low velocities is to expected. It appears doubtful, however, whether our possible enemies, having arrived, after great efforts and vast expenditure, at remarkably straight-shooting long-range guns will abandon them for relatively inaccurate weapons. This has certainly not been the practice in the past, and the resuscitation of smooth-bores—also at one time prophesied—is about an equally probable contingency. Again, though the value of curved fire of heavy shell from the coast battery against the ship is only now receiving general recognition, the use of howitzer fire from the ship supplies a ready argument against open batteries and disappearing guns. For several reasons, the result of the practice carried out from H.M.S. *Hercules* off Shoeburyness in August last, was

[1] General Sir L. Simmons stated in 1870, "What is the chance of a shot fired from an unstable platform, like the deck of a ship, striking a battery at 1600 or 1800 yards, so near the crest as to do any injury to it? I believe myself it would be absolutely throwing away ammunition to attempt it." (*R. E. Corps Papers, Vol. XVIII*). High velocity guns do not appear to have increased the chances of such a hit.

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inconclusive. The fact nevertheless remains, that though the ship was anchored in smooth water, such an excellent high-angle gun as the 8-inch 70-cwt. howitzer was unable to plant a shell within 20 yards of a conspicuous target flag at only 1500 yards, and that two rounds fired with the same elevation and charge, on the same day, gave a difference in range of 370 yards. The admirable practice obtained at Lydd with this howitzer at 2400 yards are due to back-laying and careful observation. Howitzer vessels will have to engage at ranges not less than 4500 yards, or be quickly put out of action. It has yet to be shown how back-laying is to be carried out on board ship, how under ordinary conditions the clinometer is to be employed unless the ship is aground, and how at long ranges observation from the tops is likely to succeed. The target offered by a disappearing gun will be an invisible horizontal circle, some 10 yards in diameter. The chances of hitting it may be imagined.

Some stress has been laid on the results which a modern ironclad might obtain from her auxiliary armament. Thus the *Dupérré* carries 14 5½-inch guns of new type and 12 Hotchkiss machine guns, in addition to her heavy armament. This auxiliary armament adds considerably to her total rate of fire, which, however, will still be inferior to that of a small frigate of old type. To use these guns, however, the *Dupérré* must fight broadside on, and as they have no armour protection, they would be in the same position, as far as protection is concerned, as the guns of a wooden frigate opposed to modern heavy shell fire. If the shore guns were even moderately well handled, and especially if they were supplemented by a proportion of quick-firing guns, it might fairly be expected that this auxiliary armament would be very soon put out of action with a heavy loss in men; and it might be by far the best policy for such a ship to fight end on, using only her barbettes, and—except in the case of a battery on a high site—minimizing her target.

As regards the possibility of injuring the carriages of guns in shore batteries, the experiences of Alexandria were probably unexpected. Out of 35 R.M.L. guns under fire, there were, in addition to the dismounted guns, only two cases of injury of a damaging nature to carriages—a compressor arc broken and a front truck cut away by shell splinters. The case of a small unfinished two-gun battery in Ras-el-Tin Lines, heavily shelled by the *Inflexible* and *Téméraire*, is somewhat remarkable. The embrasures in front were almost destroyed and the guns bared, yet both carriages were perfectly serviceable and were subsequently mounted at Ramleh. The Alexandria affair seems to indicate clearly that, to disable a gun, a direct hit is necessary. It is worthy of note that two 9-inch Palliser shell, which actually burst in the turret of the *Huascar*, did not suffice to render either of the two carriages unserviceable.

As to the probable effect of machine gun fire, the data, if not altogether complete, are extremely suggestive. Machine guns may be divided into two classes—1st, a continuously-fed gun, such as the multiple barrel Gatling, Hotchkiss, Nordenfelt, and Gardner; 2nd, a hand-loaded "quick-firing" gun. The former class is capable of

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delivering a very rapid fire of bullets or small shells; the latter fires shells up to about 6 lb. weight,[1] at the maximum rate of 10 or 12 per minute. At Alexandria, the fleet carried about 70 1-inch 4-barrel Nordenfelts, and expended more than 16,000 bullets. The expenditure of Gatling ammunition was only 7,000 rounds, and of Martini bullets 10,000. As to the results obtained, opinions have differed. It is submitted, however, that the number of hits on the guns and carriages of the defence may fairly be taken to afford some indication of those results. The hit of a Nordenfelt bullet on iron is generally unmistakable, but it is evidently possible that grazes at a very acute angle might have escaped observation. The total number of hits on guns and carriages was seven, and even this moderate number requires qualification. One hit was on the liberal target offered by the bracket of the Moncrieff carriage. This carriage stood upon the shore, the formality of building up protection round it having been omitted. The gun was of course not in action, and the natural fondness of the bluejacket for a good upstanding target can alone account for its being fired at.[2] The high exposed scarps of Forts Ras-el-Tin, Adda, and Pharos, distinctly showed every Nordenfelt hit, but the total number of such hits was quite insignificant. It is stated that at the Ingogo affair, where the artillery suffered severely from rifle fire, the guns were actually whitened by bullet splashes. A fair inference seems to be that the vast majority of the 16,000 bullets fell short; or, as was actually the case at Meks, flew well over the battery. Captain Fisher, R.N., states—"Most of our ships used their Nordenfelt machine guns, but nothing is known as to the effect produced. The bullets were found far and near, so it is to be feared the fire was not very accurate. It is difficult, indeed almost impossible, to see where the comparatively small Nordenfelt bullet hits." The conditions at Alexandria were not unfavourable to machine guns. The ranges of the inshore squadron were moderate, and the tops of the ships were above the level of the shore guns. Captain Lewis, R.E., in his lectures on "Permanent Fortification,"[3] remarks—"It might be quite possible for a boat armed with a machine gun to keep a heavy gun silent, that is, if the boat could manage to begin." It is not easy, however, to see why a boat firing at the water level should succeed, while the machine guns in the tops of the *Penelope* and *Invincible* failed for three and a half hours; and this opinion can only be regarded as the outcome of pure theory uncorrected by actual experience. The explanation of the apparent failure at Alexandria is, doubtless, that the ranges were, on the whole, too great for accurate practice under service conditions, and that, even at the less ranges, the smoke of the guns of the attack and defence, together with the sand thrown up and smoke caused by the shells bursting, utterly obscured the effect of the Nordenfelt guns, so that the men who served them had no idea

[1] A 40-pr. quick-firing gun, constructed at Elswick, has been tried with complete success, and gave *seven* aimed rounds per minute. A 12-pr. gun is now under construction.

[2] At least four heavy projectiles were also fired broadside on at this carriage, which received one splinter hit only.

[3] R.E. Occasional Papers, Vol. VII., 1882.

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where their bullets were going. Diagram 3 shows the influence of high sites in modifying the searching power of the 1-inch Nordenfelt gun. A fall of 2° (1 in 28) at a crest 100 feet high, can only be obtained at 1040 yards. In the case of the Hong Kong emplacements above referred to, this angle of descent is unattainable at a less range than 1260 yards.

The experiments carried out at Inchkeith, where H.M.S. *Sultan*, under the conditions stated on p. 175, concentrated her fire on a single remarkably conspicuous shore gun, form an interesting comparison with the Alexandria results. The total number of machine-gun rounds fired was 15,210, by which 15 dummies were hit. In the first four series, 1541 rounds were fired with the result of hitting one dummy. In the other series 4 Gardners and 2 Gatlings on deck fired 2815 rounds, obtaining three hits on dummies. In another 13 machine guns fired 3874 rounds, hitting two dummies. This was target practice and the dummies remained fixed in the most exposed positions which the loading numbers could occupy.[1] Making the most moderate correction for the complete difference of conditions under which an action would have to be fought, it does not appear that even a *barbette* gun has much to fear from machine gun fire, and the Alexandria results seem to be explained. The most that a ship could hope to do, by directing her whole machine gun fire on a single shore gun, would be to keep it silent for a short period at an extravagant expenditure of ammunition. A few machine guns on shore would effectually prevent even this moderate achievement.

As to the performance of the 6-pr. quick-firing gun also, the Inchkeith experiment affords some teaching. In 48 rounds, at ranges from 1500 to 1900 yards, one dummy was hit. On the other hand, in five subsequent rounds the target gun—turned broadside on—was hit three times; but since, in this case, 13 machine guns were simultaneously in action, the effect on the dummies cannot be stated. This excellent result shows the kind of target practice of which the 6-pr. is capable; but it may fairly be questioned whether its introduction has not conferred superior advantages on the defence. Against the unarmoured portions of a ship it will prove extremely effective, and to keep the crew behind their armour and the officers shut up in conning-towers will be a considerable gain. In any case, the quick-firing gun itself will probably not be carried behind armour, and the unarmoured portions of a ship may be expected to suffer very severely in the first action in which modern coast guns are properly handled.

The introduction of heavy breech-loaders for land service affects the question of protection in the following ways. The length and comparative weakness of the chase are somewhat unfavourable. Even with the otherwise complete protection promised by a casemate, cupola or turret, the great protusion of the gun will render it liable to a hit

[1] Nos. 2 and 3 stood always *on* the loading stage, about half their bodies being fully exposed. No. 5, who was supposed to serve the muzzle derrick,—a duty he could have performed with a boat hook from the loading-way in perfect security—stood actually on the platform girder, and was exposed down to his knees.

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which might easily disable it. At Eastbourne, the shell of a 6-pr. Hotchkiss quick-firing gun striking the chase of a 10·4-inch B.L. gun, penetrated into the bore. At Shoeburyness, a steel shell from the same quick-firing gun, striking the chase of a 9·2-inch B.L. gun at 150 yards, raised a bulge 0·4 inches high in the interior. The precise effect of such an injury cannot be stated. A portion of the chase of the damaged gun would obviously be blown off by the next round fired, and more serious consequences are evidently possible. The effect of a projectile from the quick-firing gun striking the face of the muzzle of a heavy gun has not been ascertained. Again a single shell from a 6-inch B.L. cut off 2 feet 4 inches of the chase of the 10·4-inch B.L. gun, and even the 5-inch B.L. is capable of inflicting serious injury at comparatively long range. To chase injuries, guns *en barbette* are not more liable than those in turrets; while long guns in casemates may evidently be seriously damaged by medium B.L. guns outside their arc of possible reply. In one sense, therefore, the introduction of long guns has reduced the value of front armour; since there is a partial anomaly involved in providing a mass of iron which, after all, leaves the weakest portion of the gun it affects to shield, exposed to injury from light projectiles. It is to be remembered, further, that the considerable amount of smoke issuing when the breech is opened constitutes an argument of some importance against mounting the new guns in casemates or roofed turrets. A breech-loader, however long, can be loaded *en barbette* while offering a minimum target to front fire of all kinds, and if the operation is performed at elevation the actual loading numbers are admirably protected by the breech of the gun itself. Unless, therefore, the fire of more than one ship can be concentrated upon individual guns, which with dispersion, careful sighting, and a moderate angle of training, will not be easy to effect, the loading numbers of new B.L. guns mounted *en barbette* will be well protected in spite of their greater distance from the parapet; while the great disadvantage attached to side loading in the case of M.L. guns—the presentation during considerable periods of a broadside target—will be obviated. On the other hand, the breech mechanism brings a new source of danger. A mere burring up of the breech-screw by a machine gun bullet, or the cutting away of the locking lever by a shell splinter, might suffice to silence the gun for a long time. These risks can, however, be easily met by a steel hood enveloping the breech, or by special steel protection to individual points of weakness.

Von Scheliha, in his treatise on "Coast Defence," says,—"guns mounted *en barbette* may always be disabled by an ironclad." The remark might with advantage have been made more general. All guns, however mounted, *may* be disabled by an ironclad, and the question is merely one of comparative risk. The Grüson plates of the great Spezzia cupola, 4 feet 2 inches thick, and each weighing very nearly 91 tons, will provide no protection whatever for the long weak chases of the two 16-inch guns, which could be disabled by the projectile of a 5-inch B.L. gun carried on board ship. Under these circumstances, it is not surprising that the barbette principle still finds favour, and that it is not proposed to give front armour protection

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to any of the guns mounted in the new coaling station defences. A barbette gun cannot well be disabled except by a direct hit, and the vulnerable target presented to front fire is little larger than the breech section. It has been asserted that the new B.L. guns cannot be held in a *barbette* mounting, and that turrets, cupolas, or casemates fitted with cumbrous "yokes" are, therefore, necessary. The 9·2-inch B.L. gun has been held at Lydd by an extemporized anchorage in shingle, and has also been successfully mounted on board ship. The 10-inch B.L. has for some time been mounted *en barbette* at Cadiz, and successfully fired. The 43-ton 12-inch has also been tried on a *barbette* mounting. This objection may, therefore, perhaps be abandoned.

The drawbacks to this mode of mounting are two—exposed flanks, and the absence of over-head cover to the detachment. The maximum angle at which the gun can subtend at the ship—in other words, the area of the target—can be limited to any extent desired; while the practical carrying out of systematic cross firing from ships will not be quite so easy as it appears on paper. The ship may be expected to show a natural tendency to concentrate her fire on the guns which are hitting her; and if the *Inflexible*, at Alexandria, had been hulled every other minute from Oom Kabébé, she would not, in all probability, have divided her fire so impartially between this work and Fort Ras-el-Tin.

Of all methods of mounting yet proposed, the disappearing principle offers the greatest advantages, and provided that the mechanical difficulties can be overcome, this method will receive a wide adoption. The gun, laid under cover by a position-finder, will be vulnerable only for a few seconds before each round. Its exact position can only be identified during the brief period of visibility. There appears to be no satisfactory mode of attacking it.

The experiments carried out at Portland Bill, in November, 1885, give some idea of the difficulty a ship will experience in dealing with a gun of this class. The dummy—a wood and canvas model of a 10-inch B.L. gun—appeared and disappeared on the natural surface of the bluff, working up and down through an opening in a wooden shield at the ground level. The period of visibility laid down by the conditions of the trial was half a minute in every three minutes, and a small charge of powder was fired electrically at the moment of disappearance to represent the discharge of the gun. H.M.S. *Hercules*, at ranges varying from 750 to 950 yards, fired 6,910 rounds in ten minutes from 1-inch and rifle calibre machine guns, and 29 rounds from the 6-pr. Hotchkiss quick-firing gun. The whip used for hauling down the dummy unfortunately broke at the end of the 7th minute. For the three following minutes, therefore, the dummy was exposed and, as the ship continued her fire after the bearing laid down had been passed, it presented a broadside target. Notwithstanding that the dummy was exposed more than twice as long as it was intended to be, and about four times as long as a real gun need have been, it received only 16 direct and 9 splinter hits. The horizontal wooden shield showed four scratches, and one Nordenfelt bullet dropped into the gun pit. It would, of course, be perfectly useless to employ machine gun fire at a disappearing gun; but the above result supplies

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an interesting comparison with that obtained by a similar armament at Inchkeith. To halve the number of hits obtained at Portland, so as to correct for the unfortunate accident to the whip, is more than fair, since the greater portion of these hits were undoubtedly obtained when the gun had ceased to be disappearing and presented a broadside. Accepting this correction, the comparison of hits on the guns at Inchkeith and Portland is about 12 to 1, although the average ranges in the two cases were as 1000 to 825 yards respectively. In addition, 15 rounds of 10-inch common shell and 13 rounds of 10-inch shrapnel were fired at the Portland dummy at ranges from 2,200 to 2,845 yards without any result whatever. In the common shell series, the error in range varied from 300 yards short to 300 yards over, and the horizontal dispersion 120 yards left to 150 yards right, showing clearly the difficulties of practice against such a target.

The above experiment, although by no means satisfactory from either the point of view of the attack or defence, serves nevertheless to substantiate the advantages claimed for the disappearing system. These advantages can obviously be reduced to a minimum, however, by applying the system as at Newhaven, Popton, Hubberstone and Corradino Lines, Malta.

The general conclusions which it has been sought to arrive at, may be stated as follows:—

1. The all-round protection conferred by the turret will be sure to recommend it, but expense, combined with other considerations, will limit its adoption to low, cramped, advanced, or island sites. The great range of modern guns will somewhat check the tendency to push forward the shore gun to the water's edge, where a high site suitable for a *barbette* is available within a few hundred yards to the rear. In any case, the provision of a turret can be justified only where a disappearing mounting is proved to be impracticable. Limitations of range due to considerations of the size of the port of a turret will not be tolerated. The heaviest guns will therefore be port-pivoting, and will be worked by hydraulic power, proved to be perfectly successful on board ship. At distant foreign stations, where there are no facilities for repairs, the turret can, under no circumstances, be adopted. In very hot climates it may prove inadmissible. Where there are moderately high sites of sufficient area it is altogether unnecessary. The relative inaccuracy of the fire of ships, renders it probable that a turret would not be frequently hit in action, and the fact that, as proved at Buchau, a single segment of a Grüson turret broke up under four closely adjacent hits from a 12-inch gun, does not condemn chilled-iron armour. Such a favourable result would never be attained by ships in action. The question between wrought-iron, steel, and cast-iron armour is, therefore, mainly one of economy. A sand or earth parapet up to the level of the glacis plate will be provided, where practicable, as at Kronstadt. In other cases, a gentle slope of hard concrete will be substituted.

2. The cupola, understanding by the term a conical turret containing a single gun worked by hand, is subject to some of the above limita-

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tions. The Eastbourne experiments showed that a cupola, the strongest plate (7-inch compound) of which was shattered by three 8-inch B.L. shrapnel striking blind, approached the limit of hand working. The adoption of a floating pivot would doubtless facilitate rotation to a great extent; but it seems probable that a cupola to justify its existence must carry a weight of armour necessitating the employment of power, and thus become subject to the same limitations as the turret, of which it is a mere modification. An inadequately armoured cupola appears to be quite as dangerous as a *barbette* mounting, while it is far more expensive.

3. The continuous iron front or the Grüson battery may still be employed under certain circumstances,—for example, on a cramped low site where great volume of fire is required over a limited arc, or where an all-round fire is needed of limited intensity on a given arc, but such that the flank and rear guns shall be available after those in front have been silenced. In such a case, 'position finding' would be a necessity; since the smoke produced by the large charges now employed renders the direct laying of casemate guns entirely dependent on chance conditions of wind and weather. Armour may also conceivably be desirable to protect machine or quick-firing guns in connection with turrets. This form of protection will usually labour under the disadvantage of offering a large target, and involving heavy expense, while it will sometimes entail crowding of guns where dispersion is possible. As in the case of the turret, range cannot be sacrificed to size of port, and port-pivoting, probably necessitating hydraulic power for the larger nature of guns, must be adopted.[1] The thickness of metal in an armoured front should be well able to withstand the heaviest projectiles that the attack is likely to bring to bear upon it, and the possibility of subsequent strengthening should not be lost sight of. Since cast-iron armour cannot well be subsequently strengthened, a Grüson battery should possess a resistance decidedly greater than that now required.

4. The disappearing principle will undoubtedly attain great development, no other mode of protection confers equal invisibility. A disappearing gun in a well-placed pit provided with a horizontal splinter-proof shield is far better protected than in an impenetrable turret. Moreover, a gun so mounted possesses the great advantage that future advances in the offensive power of ironclads are little likely to diminish the value of its protection. For the new breech-loaders the counterweight carriage is unsuitable, and hydro-pneumatic mountings have not yet by any means reached their full development. It has been shown that these mountings can be satisfactorily applied to the 8-inch B.L. gun,[2] and experiments shortly to be tried will test

[1] Port-pivoting has already been partially attained by the "small-port" carriages adopted for 10-inch and 12·5-inch M.L. guns, but entails the great disadvantage that the field of view is extremely limited. Guns thus mounted would, therefore, be best laid by the aid of a depression position-finder.

[2] The fact that this mounting—on its first trial—stood 46 rounds, including 5 rounds with 210 lb. proof cylinders, with charges varying from 106 to 112 lbs. Prism[1] (black) without a break down, is most encouraging.

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their application to the 9·2-inch and 10-inch B.L. Experts hold that the principle can be extended without any great difficulty to the 68-ton B.L. gun. Were several adjacent guns to be thus mounted it may prove desirable to provide a small steam engine, able, by pumping, to ensure the maintenance of the pressure necessary to raise the guns. The engine would be merely a reserve of power, intended to save manual labour and to meet the case of leaky glands or defective cup leathers. For the old muzzle-loaders there is no reason that a counterweight system, such as that of Colonel Moncrieff or Major King, should not be employed, for guns up to the 10-inch R.M.L. The system need be applied only in cases where low sites, with deep water within short range, are unavoidable. The Moncrieff mounting is necessarily costly, but the gun is far better protected than if mounted in a casemate with a heavily armoured front, while, in the opinion of the Special Committee appointed to consider the question of counterweight carriages, one disappearing gun may be estimated as equal to two in casemates. A simpler system may possibly be devised and rate of fire might perhaps be sacrificed in consideration of the great protective advantages. The value of the disappearing principle greatly depends on the way in which it is applied to the actual site. With adequate care, the position of a gun so mounted may in most cases be rendered absolutely indistinguishable except during the few seconds of exposure before firing. If, however, this fact is not fully recognized, the system loses one of its special advantages.

5. The principle of the *Collingwood* mounting (Plate II.) appears to be eminently applicable to coast defence guns of the heaviest class. The measure of protection provided is practically equal to that of a turret. It is true that this protection is far inferior to that conferred by the disappearing principle, but the practicable difficulties in the case of the heavier guns are possibly less. The target offered to the ship is so small that the comparatively slight risk of a direct hit—almost the sole danger to which a gun thus mounted is liable—may perhaps be accepted without hesitation. The loading numbers have complete security. With the heavier guns, hydraulic power must undoubtedly be employed, and there appears to be no better mode of applying it. Whether the hydro-pneumatic principle can be applied to this mounting, so as to realize a storage of recoil, and enable several guns to be worked by a small engine, remains to be seen. The addition of an armoured glacis will be desirable in the case of low sites, and it is possible that chilled iron may be suitable for the purpose.

6. The *barbette*, with a central pivot, is likely to be the most general form of mounting. The heaviest of the new guns at present tried with this mounting is a 43-ton B. L. gun, firing a charge of 400 lb. Whether heavier guns, up to the extreme limit of hand working, can be thus treated remains to be seen. With the larger natures a front pivot may be necessary, and hydraulic power must be employed. The main danger of the *barbette* mounting is on the flanks, and protection should rarely be sacrificed to a wide angle of

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fire, where it is possible for an unengaged ship to take up a flank position. An angle not exceeding 120 degrees, with bonnettes, will be the most generally suitable; but to lay down an arbitrary limit is evidently undesirable, and each case must be dealt with on its merits. Circular pits are objectionable, but much less disadvantageous on high sites. The emplacement should have the minimum possible of exposed masonry above the line of descent of heavy projectiles fired at a range of 3000 yards. It may prove desirable to protect with iron the crest over which the gun fires, especially where considerable depression is required. The Eastbourne experiments show that a skin of iron plate supporting good concrete, would be a suitable form of crest; but it is possible that the place of concrete may advantageously be taken by sand alone. The range must not be diminished by limiting the possible elevation. Since the carriage designed at Elswick for the 43-ton gun admits of 20°, this limitation would not appear to be necessary. The protection of exposed gear on the side of the carriage and of the breech-screw (when withdrawn) from the chance hit of a shell splinter, as well as the whole question of steel hoods to cover the loading numbers, merit careful attention. Under some circumstances, the front pivot and embrasure will be advantageous. It is now certain that the results of experiments with siege guns need not be held to condemn the embrasure for coast batteries. Should the difficulty of under-cover loading for the existing M.L. guns prove incapable of satisfactory solution,[1] it may be worth while to accept the limited angle of training and adopt the embrasure for these guns, mounting a larger number of guns to cover the same field of fire, in order to gain the considerable protection against shrapnel and machine guns which the embrasure affords to the loading numbers. Bonnettes with vertical stone cheeks 8 feet high, as at Fort Leonardo, Malta, and elsewhere, will scarcely be repeated, and earth or sand will be universally employed. Guns *en barbette*, except in cases where a sky background cannot be avoided, may be rendered almost invisible at moderate ranges. Even the 100-ton guns at Malta are extremely difficult to make out at 2000 yards; those at Gibraltar could easily be rendered at least equally inconspicuous.

7. In sighting guns, dispersion will be aimed at as much as possible, and the placing of the most powerful guns of a battery in closely adjacent emplacements will always be avoided. High sites will be preferred for open batteries. Against the more heavily armoured modern ships, the attack on the deck may possibly prove by far the most effective course. *Barbette* ships seems specially ill-qualified to resist such an attack. The very accurate fire of the new guns will be favourable to it. It is true that the flatter trajectories will produce a relatively greater tendency to rebound from the deck plating; but, on the other hand, there are plenty of objects on the deck of a ship capable of turning down a projectile, and once turned down it would

[1] The chain rammer experiments carried out with a 9-inch R.M.L. gun, at Eastbourne, in July 1885, cannot be regarded as altogether satisfactory. The average time per round was 3 mins. 19 secs., and the difficulties of ramming increased after a few rounds.

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be rash to attempt to predict its further course. The importance of high sites and dispersion was clearly pointed out by Sir Harry Jones 40 years ago,—"It becomes the duty of the Engineer charged with the defences of a maritime fortress so to arrange his batteries, that the defence may be from several points distant from each other . . . . on commanding situations and not *à fleur d'eau* which has heretofore generally been the case. As auxiliaries, batteries so placed, on many occasions will be found very useful; but for the principal defence, height must be attained."[1] Todleben drew the same moral from the remarkable effect produced by the fire of the Telegraph battery at Sebastopol, and naval men have never hesitated to own their dread of plunging fire. There is no ship afloat which could not be put out of action by such guns as the 6-inch and 8-inch B.L., mounted on high sites, and it may be desirable in some cases to sacrifice even a thousand yards of range to gain the double advantage of plunging fire, and relative immunity from risk.[2]

8. Invisibility will be striven for by all possible means. It is the cheapest form of protection. Guns will be suitably coloured. Clean cut lines, and even slopes, will altogether disappear, while vegetation will be judiciously encouraged. The background and foreground of gun emplacements will be made the subjects of careful study. At Alexandria, the great difficulty of our ships was to find a definite object to aim at. In a well-designed earth battery there should rarely be anything clearly defined. The very few natural advantages of the Alexandria sites can be improved upon in most cases, provided that the necessary amount of care and thought is forthcoming.

9. Parapets 35 feet thick, with flat exterior slopes, will be ample for all purposes of protection, and are likely to be equally serviceable years hence. Sand will be employed in front of gun emplacements wherever possible. A mere layer two or three feet thick on the top of an earth parapet has been found to be advantageous.

10. Since it is now certain that ships will have to anchor, or come back to a given point to fire, when seriously engaging earth batteries, the employment of curved fire against them will in time obtain wide adoption. The fact that, with an 11-inch howitzer at 7,300 yards, five shots out of ten were placed on a target representing the deck of the *Inflexible*,[3] is sufficiently significant. Later experiments in Russia and Italy fully bear out this excellent result, while the depression position-finder opens out new possibilities. Already the Italians are mounting howitzers in large numbers for coast defence—at Venice, the numbers of howitzers and guns are 45 and 22 respectively, three forts being armed with howitzers only. The U. S. Board on Fortifications propose 144–12-inch rifled mortars for the defences of New York

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[1] Editor's note—"Peninsular Sieges."

[2] Diagram 4 (prepared by Captain T. S. Jackson, R.N.) gives the trajectories of the 10-inch R.M.L., fired horizontally, and with 5° and 10° depression, and of the 9·2-inch B.L. with 5° depression.

[3] Journal R.U.S. Institution, 27th January, 1882.

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alone. The heaviest ironclads are exposed to deck attack by means of curved fire, and the moral effect of this fire, delivered from small groups of heavy howitzers will suffice to prevent them from anchoring or even manœuvring at slow speed within range. The service 9-inch R.M.L. gun, re-tubed and polygrooved, has given excellent results used as a howitzer. The larger natures of short R.M.L. guns will before long be similarly utilized and will be much improved in range and accuracy. The proper employment of large howitzers is to group them in fours behind natural folds of ground, or banks rendered indistinguishable from their surroundings, employing salvo-fire directed by a position-finder. The re-tubed guns will, in many cases, be adapted also for direct fire; but, when thus used, their value, as howitzers is impaired by their necessarily increased visibility. It is, therefore, desirable to regard the two modes of employment of these guns as completely distinct, and while mounting them in some cases so as to retain the power of direct fire at moderate ranges, to provide concealed howitzer batteries in addition.

11. The defence will employ machine and quick-firing guns in dispersed emplacements, well separated from those of the heavy guns. This auxiliary armament can be rendered practically invisible at moderate ranges, and should find no difficulty in keeping down the fire of corresponding guns on board ship, as well as thoroughly searching the unarmoured portions.

12. The advantages in respect to range-finding and the direction and concentration of fire which the shore battery possesses over the ship deserve to be utilized to the utmost possible extent. The position-finding system devised by Major Watkin, R.A., has attained perfection. Its practical value has been amply attested by experiment, and its general application cannot be much longer postponed.[1]

In conclusion, it is maintained that, having regard to future possibilities, the defence must proceed rather in the direction of scientifically increasing the many tactical and other difficulties of the attack than in merely piling on front armour. It may be doubted whether thickness of iron or steel will ever exercise a determining influence on an action between ships and coast defences. The *Amiral Baudins* and *Lepantos* can be defeated without ever penetrating their thickest plates. The want of practical experiments in naval gunnery has naturally resulted in anticipations as to the effect of the fire of ships, which can never be fulfilled. Without waiting for Alexandria, it could probably have been established that vessels in motion are quite unable to silence guns in dispersed emplacements even at low levels, and this fact alone would have been worth ascertaining. There are many more points on which light might have been thrown by such experiments as those at Inchkeith and Portland. The back of the Rock of Gibraltar, the Island of Filfilla off Malta, offer convenient sites; while a suitable island could probably be found on the west coast of Scotland. The

[1] The Russians have had a system of position-finding in practical operation at Kronstadt and Sebastopol for some years.

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expense would surely be justified; since after all the chances of being hit materially affect the settlement of most questions of coast defence. If such questions are to be ruled mainly by mere considerations of armour penetration, and the battle between coast defences and ships is regarded—as has sometimes been the case—in the light of a mere contest between the gun and the plate, how are we to forecast the the future?

Lecturing in 1873,[1] Lieut. (now Major) English, R.E., one of the most able exponents of the iron method, stated—"The development of curved fire, which would appear to be the most likely method of attack, would surely not be such a difficult task as the development of armour-piercing projectiles. It is almost certain that no material improvements will be made in the shape and material of the latter; and it appears probable that the limits of weight and velocity are already nearly reached, on account of the difficulty of finding any material to withstand the strains produced in the inner tubes of heavy guns by the enormous charges even now found requisite. We may, therefore, venture to hope that comparatively little, if any, further expenditure will be necessary to maintain the present invulnerability of our iron coast defences."

Curved fire from ships cannot be said as yet to have received any "development,"—unless, indeed, the proposed construction of a cruiser carrying four Zalinski air-guns for the United States navy can be regarded in this light. Meanwhile, the improvement in armour-piercing projectiles has been extraordinary, as was brought home to most minds by the recent performances of the Firminy shell. The 12-inch 35-ton gun of 1873, has a muzzle velocity of 1390 f.s.; the 9·2-inch B.L. wire gun of to-day has 2500 f.s. The maximum internal strains are being reduced.[2] The projectile of the 35-ton gun weighs 714 lb., that of the 100-ton guns, now several years afloat—the *Duilio* was launched in 1876—weighs about 2000 lb. The 10-inch R.M.L. of 1873, burns 70 lb. of powder; the 10-inch B.L. of 1886, at least 250 lb. The inadequacy of most of our "iron coast defences" is a matter of common notoriety, and large sums would be needed to restore an "invulnerability," which was even rendered doubtful by the introduction of the 38-ton gun in 1874.

With such an awful warning of the dangers of prophecy in regard to iron defences, it is surely in other directions that we must seek to meet the requirements of the unknown future.

LONDON,
December, 1886.

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[1] R.U.S. Institution; 31st March, 1873.

[2] Thus, in the 100-ton R.M.L. gun, 469 lb. P^2 gave a pressure of 20·8 tons; while 551 lb. Fossano powder produced only 17·37.

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PLATE I.

Fig. 1.

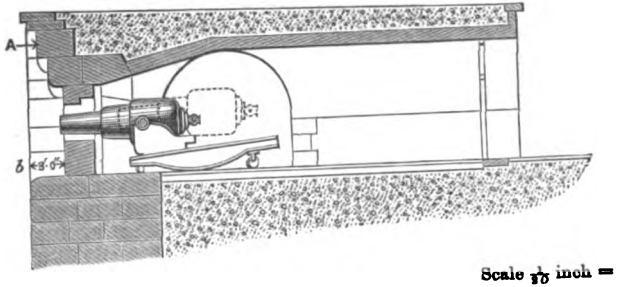
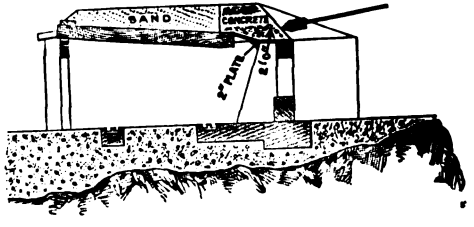


Fig. 2.



Scale $\frac{1}{10}$ inch = 1 foot.

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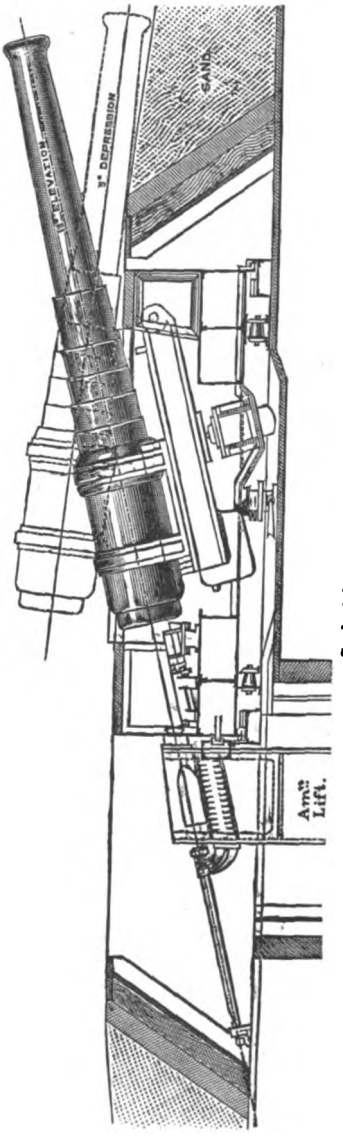
PLATE II.

"Collingwood" *barbette* mounting for two 43-ton B. L. guns (Land Service).



Scale 1 inch = 10 feet.

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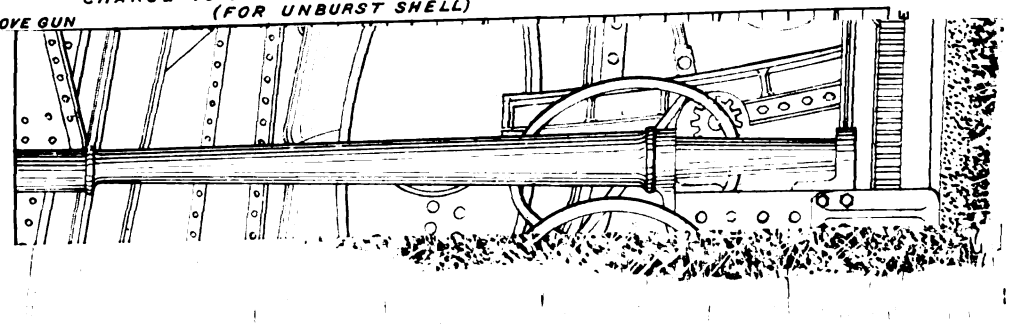
TABLE. I. ANGLES OF IMPACT OF PROJECTILES FROM 10 INCH M.L.R. GUN.
CHARGE 70 LBS. MUZZLE VELOCITY 1364 F.S.
(FOR UNBURST SHELL)

HEIGHT IN FEET OF OBJECT ABOVE GUN

'DRO-PNEI
'ROM THE IN
'N LOADING PO
Scale about



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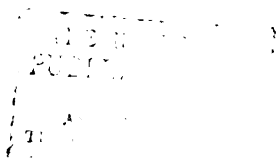

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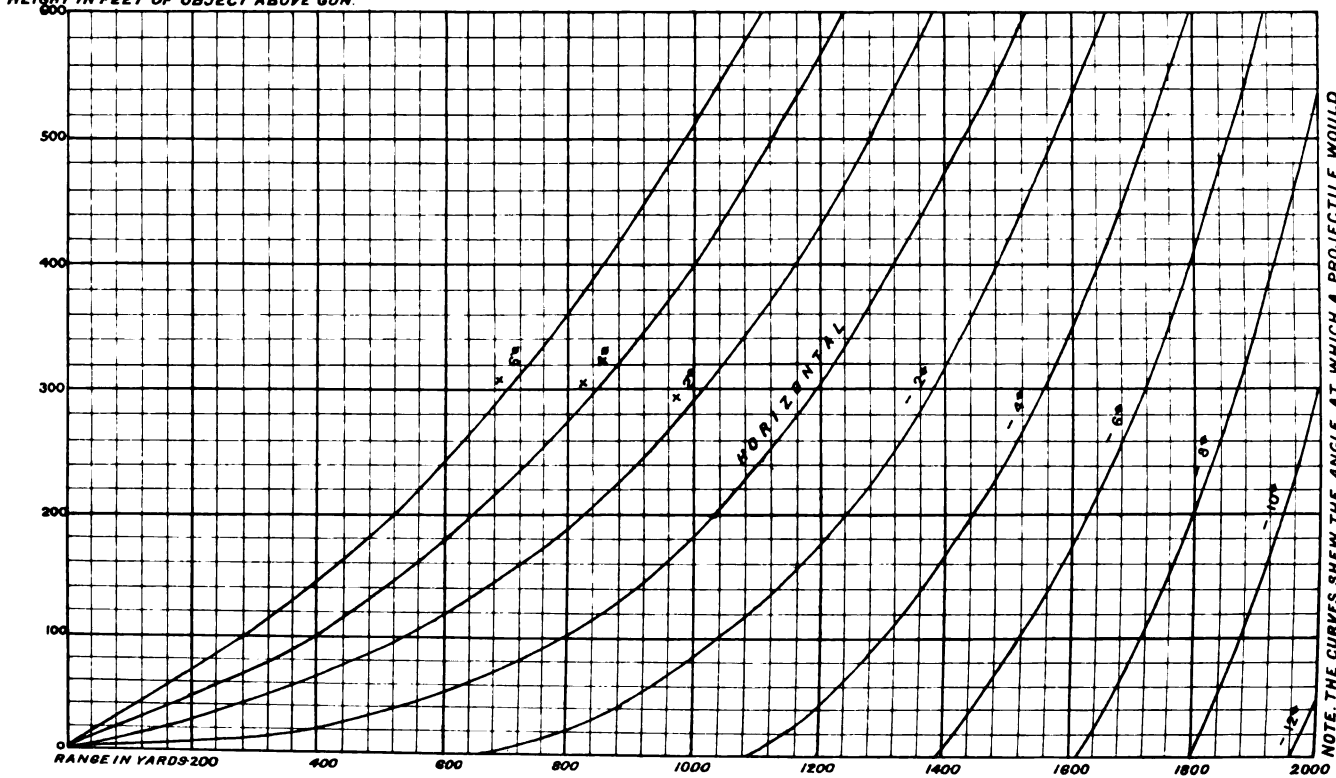
TABLE.3. *ANGLES OF IMPACT OF PROJECTILES FROM 1 INCH NORDENFELT GUN.*

WEIGHT OF SHOT 7·25 OZ. MUZZLE VELOCITY 1417 f.s.



Vincent Brooks Day & Son, Lith.

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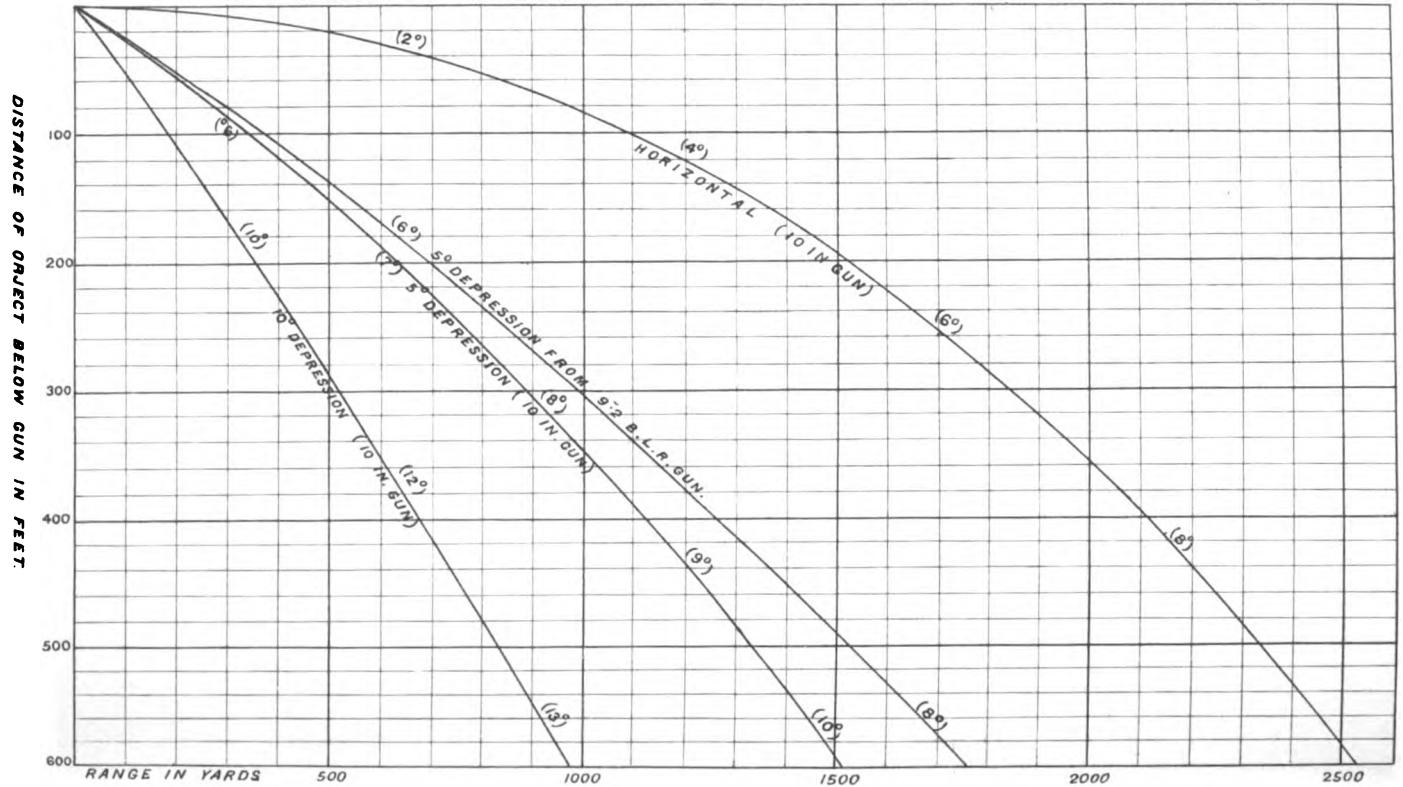
TABLE.4. *TRAJECTORIES OF PROJECTILES FIRED FROM 10 INCH M.L.R. GUN (HORIZONTAL AND WITH 5 & 10 DEPRESSION*

CHARGE 70 LBS. M.V.=1364 F.S.

ALSO OF SHELL FROM 9·2 B.L.R. GUN WITH 5° DEPRESSION – SHELL WEIGHT 380 LBS. M.V.= 1900 f.s.



FIGURES IN BRACKETS SHOW THE ANGLES OF TANGENT TO TRAJECTORY WITH HORIZONTAL LINE

Vincent Brooks Day & Son, Lith.

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THE NILE EXPEDITION OF 1885.

BY

COLONEL F. DUNCAN, C.B., M.P., R.A.

A Lecture delivered at the Royal Artillery Institution, Woolwich, Wednesday, 6 October, 1886.

COLONEL DUNCAN.—Gentlemen, the Nile Expedition was not a storm out of a clear sky. The circumstances which had preceded it and which gave it birth, were of an interesting and almost dramatic character; and on these I should like to dwell briefly before we enter on the Expedition itself.

I want you first to bear in mind the reason why we were in Egypt at all, and also why we suddenly seemed to have the administration of the country thrown upon us.

The total collapse of the power of Arabi at Tel-el-Kebir, and the immediate occupation of Cairo by the English, seem to have found our government at home in an almost unprepared state, and they were hardly ready to take up so soon the question of administration; but among the decisions at which they arrived, there was one which was to have a very material effect upon their after policy,—namely, that they would have nothing to do with the trouble then existing in the Soudan. In justice to the Government of that day it is well therefore to remember that from the very first—not merely after Hicks' defeat, but from the very first—they sought to avoid any interference with the troubles which were going on in the Soudan, which seemed to them to have a great deal to do with religious excitement, but which were really due to other causes.

Having made up their minds that they must rule Egypt until some other army could be created in place of that of Arabi, the Government decided that they would try and educate the future Egyptian army upon English lines; and that for that purpose they would lend a certain number of English officers as instructors, for a period of two years. They also got the Khedive to order that the recruits—who were conscripts, as in all previous Egyptian armies—should be assured, on being taken from their villages, they would never be called upon to serve in the Soudan, in the hope that this assurance might make the service in the army more popular than it had hitherto been. You will see presently how much stronger circumstances were than statesmen,

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and you will find that this very army, which was assured that it was not to go into the Soudan, practically was altogether in the Soudan at the time of the Nile Expedition. They also decided to do something for the fellaheen, in the way of irrigation works in Egypt, and also in seeing that the water was more equitably distributed amongst all ranks and classes. Perhaps in no particular was reform more needed than in that. The gross tyranny and selfishness of some of the ruling classes amongst the Egyptians in absorbing, at critical times of the year, all the water they could get, leaving the fellaheen without, was one of the greatest evils of the past history of Egypt, and you must bear in mind that *the Nile is Egypt*. They also decided that they would have a police force, officered partly by Europeans, but not by officers on the active list of our army,—in fact, at the commencement, this police force was officered in many cases by Austrians and Italians, as well as by Englishmen.

As I have already stated, the Government point-blank refused to have anything to do with the hostilities or with the army in the Soudan, but they raised no objection to the employment of retired English officers, such as General Hicks, or to the employment of officers who had been in the English Militia, and of English civilians, in the force which afterwards met with such a terrible fate.

This was the state of affairs at the beginning of 1883. The reforms were in full swing, and were making most remarkable progress—especially those in connection with the irrigation works, and with the army—when suddenly an outbreak of cholera on a very large scale did much to check the further progress of the reforms, because it sent the army scattered over the desert in cholera camps, and the police were employed upon other than in police duties, as cordons round infected towns, while many of the European officials, whose duties admitted of it, left the country. The cholera lasted practically for the whole of the summer. In the month of December the news came of the total defeat of Hicks' army.

Now for a few words about Hicks and his army; and what I shall tell you about the probable fate of that army, is what I have gathered (having myself picked up a little Arabic) from men who were with him, and from some who were either in the battle itself, or immediately close to it. Hicks, an able and gallant man, went up with great energy to Khartoum, but with the most ghastly army I ever saw in my life. I saw many of them brought in from their villages, chained to one another, and with a species of wooden collar round their necks, and taken away to Suez—a nice preparation for developing a martial spirit! On reaching Suakin, General Hicks had to take this "army" across to Berber, and he succeeded not only in taking the army across, but also in taking siege guns, to be used in the fortification of Khartoum. These were the eight and nine-centimètre Krupp guns. The way in which they were carried was this:—two camels went in a sort of tandem, with poles connecting the two saddles, and the guns were slung between those poles. With that method of transport he succeeded in reaching Khartoum with his guns.

On getting there, not being under the ægis of England, he found

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the old difficulty about getting pay and food for his men, and he was driven almost wild by the intrigues of the local pashas; but he succeeded in licking this army into shape, and in defeating the Mahdists at a place not very far from Khartoum. He for a long time resisted all the pressure that was brought to bear upon him from Cairo, to go to El Obeid and defeat the Mahdi. It was thought that if he did that, the result would be very striking, and put an end to all the troubles; but he knew that his army was not yet capable of doing it, and he resisted the pressure that was brought to bear upon him, especially by Omar Lufti Pasha, the Minister of War, and Abd-el-Kadr Pasha, who had been formerly a strong and successful Governor of the Soudan. Hicks at last yielded, and, as you know, met with a disastrous defeat. He was deceived by his guide and led to a place where no water was to be had. Most of the men, tortured by thirst, quitted the ranks, and about two-thirds of them went away in the hope of getting water; the remaining third, which included all the English officers, was surrounded by the Mahdi's troops. The two-thirds who were away are believed mostly to have joined some of the other garrisons that were holding out to the south of Khartoum: the whole army was certainly not destroyed, because, as I have said, I heard this account from witnesses of what had happened, and from some who had possibly been amongst the two-thirds who had quitted their posts and gone in search of water.

When the news of Hicks' defeat reached Egypt, the first thing that our Government did was to urge the Egyptians to evacuate the Soudan altogether. There I think they committed a tactical error. If they wished to evacuate the Soudan they should have done it without speaking about it, because the announcement was a practical admission of defeat, and when that admission was made, the waverers would naturally join the side of the conquering body, the followers of the Mahdi.

But in the meantime troubles were springing up in the Eastern Soudan, and Osman Digna was expected to come across to Lower Egypt, while the advance would be made by the Mahdi's people from Upper Egypt. It was necessary therefore to send an army to Suakin to defeat Osman Digna, or at all events to occupy him. Unfortunately the English Government refused as yet to withdraw the rule which prevented the Egyptian army from going beyond Egypt proper, even for its defence, and a wretched collection of untrained men, unfamiliar both with their officers and with their weapons, was sent under the gallant Baker Pasha to meet Osman Digna, and, as you know, they were completely defeated at Teb.

We may now concentrate our attention on the Nile. The action taken at this time upon the Nile by the English Government was to accept an offer made by General Gordon to go up to Khartoum himself, and to endeavour by his personal influence, which was very, very great in the Soudan, to effect the withdrawal of all the officials.—that is to say, not merely the civil but also the military officials,—to Egypt proper, leaving the Soudan to the Soudanese. He went up, accompanied, as you know, by Colonel Stewart, but unattended by any

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armed force, crossed the desert from Korosko to Abou-hamed by camel, instead of following the river—went from Abou-hamed to Berber and from Berber to Khartoum, meeting with no resistance, but being received with welcome everywhere. When he got to Khartoum, his reception there encouraged him to believe that he would be able to carry out what he had undertaken to do. There is no doubt that at that time the Soudanese had not quite realized that the evacuation of Khartoum by all the officials was contemplated, because that also meant the end of commerce, by which all those people lived; but as they gradually realized from seeing these officials day after day sent away by Gordon, that Khartoum was to be abandoned to its fate, the step taken by them was to surround Khartoum, and to keep Gordon there. It was arranged that an officer was to be sent up to Assouan to receive the convoys of refugees as they came in, and to distribute them to their old homes, or to any homes they might choose to select. I was the officer entrusted with this duty.

There is one division of labour in Egypt which in theory is admirable. Egypt is divided into provinces, ruled by men called *mudirs*. Each province has its own treasure-chest, collects its own taxes, pays its own officials, and remits the surplus to Cairo. The *mudir*, assuming him to be a benevolent despot, is able to do an immense deal of good, but he is a despot all the same; and as a fact the *mudirs* have generally done an immense amount of harm. To an officer sent up, as I was, to distribute these people to their homes, and with full power over the administration of the country for that purpose, the advantage of being able to use the *mudir* for the purpose of getting transport and money and food was very great, and this system of decentralization, assuming the *mudir* to be a good man, is an admirable form of government. The railway from Cairo to Assiout is almost as bad as some we know in England, but in time, after 12 hours, I arrived there. Assiout became a very important point in the line of communication during the Nile Expedition. It was there that the troops took to boats, leaving the railway; all the stores were shipped there, and the Commandant belonged to our own Corps, a very excellent Commandant, Colonel Lloyd. On leaving there, the state of the river, as it then was in March, 1884, was such that it took me between five and six days to steam to Assouan. The *mudir* resides at Esneh, and we subsequently got through him and his agents all the transport that was required for the refugees.

On reaching Assouan my orders were to make arrangements for the reception of these unhappy refugees whom General Gordon was to send down from the Soudan, and to fortify Assouan to some extent.

Assouan is a very ancient city. It is mentioned by the prophet Ezekiel as the city Syene; it is surrounded by basaltic hills, and has given the name to the stone called "syenite." It is a very unhealthy town, and the place I selected for the troops was on the high ground to the south of Assouan. A good deal of sensation was excited in the town by the arrival of the troops, and of "an English Pasha," as I was called, and it took a very amusing form. One man came to me on almost the first day, and said that he had a lawsuit with another man

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which had been going on for years, and that unless he paid more money he could not obtain a decision, and he begged me to decide it. I said, "if you will go to the other litigant and can agree with him to accept my decision, whatever it may be, I will hear what you have to say; but unless you first both make that promise I have not time to consider it." He went away, and presently they both came to me, contented to accept my decision; both of them told their stories, I gave my decision, and to their amazement asked no money for it. That night I was lying on the ground outside my tent, and I was awakened by a noise, and saw a number of people streaming into the camp and sitting down in rings smoking cigarettes in true Arab fashion. I told my servants to ask what this meant, and the people told them they had heard in the villages around that an English Pasha had come who gave his decisions for nothing, and they hoped to get him to decide their cases. They kept me awake all night with their talking, and I began to suspect that in the Arab heart there was the same sort of feeling that underlies the Western legal maxim, *vigilantibus, non dormientibus, jura subveniunt.* As a matter of fact, they thought it wise, I suppose, to be *vigilantes* that night.

This row of hills was ultimately completely covered with fortifications and huts. Assouan is below the First Cataract, and immediately above, at a small place called Shallal (which means "cataract"), was the place where the refugees who came down in the boats were received by me, and there for a time I kept them. I never let them go near my young troops, because in the first place most of the old soldiers were frightful sights to look at, from age, and wounds and sickness—enough to appal young soldiers; and in the next place, I thought they might terrify my men by exaggerated descriptions of the Mahdi's power. I also placed a separate camp for the women who had come down. After settling claims and issuing food, we carried them down, by means of a small railway, and put them on board the boats below the cataract, and sent them away.

They arrived first to my care at Korosko. General Gordon himself, with Colonel Stuart, started them off from Khartoum, with all the papers he could give them, and with a certain amount of money advanced. On reaching Berber there was a man there called Cuzzi, an Austro-Italian merchant, who had been appointed as acting Vice Consul for England by General Gordon on his way up to Khartoum; and this man was told to undertake a further advance of money, and to telegraph to me every day the number despatched to Korosko. At Abou-hamed we had a sheikh who supplied the camels and sent the refugees across the desert, a hundred at a time. It was five or six days march, and there was water at only one place; but so admirable were the arrangements insisted upon by General Gordon, that I never found that there was any distress from want of water, and they had always enough of the simple food which suffices for the Egyptians.

But to go back to poor Cuzzi: his story is rather dramatic. Later on, when the wire from Khartoum was cut, he telegraphed to me that he was rather uneasy, and that he would like to get away and go into Egypt with his family. I reasoned with him, but he was very

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pertinacious, and I telegraphed to Cairo for instructions, and asked that one of the English Officers who were with me might be allowed to go up in Cuzzi's place, because I thought it very important that a representative of England should be there at the time. The answer I got was that Cuzzi might come away, but that at present it was not intended to replace him. I gave him the permission, and after staying for two or three days he started. His was the last convoy that started, and he was captured. Poor Cuzzi was offered his choice of death or becoming a Mussulman. I do not think Cuzzi was a man of very strong moral fibre, for he preferred to become a Mussulman. He was at once circumcised and sent back to Khartoum with a letter to General Gordon, urging him to surrender, because the whole country was in the power of the Mahdi. When, however, his name went into General Gordon, a message came back that the General would not see a man who cared more for his miserable life than for his God. Cuzzi was then sent on to El Obeid, and nothing more was heard of him.

At Korosko, I had a German named Giegler Pasha to help me, who had been employed in telegraph work in the Soudan, and who had given great satisfaction to General Gordon when he was Governor there. This man had a young German wife, and one reason why he was put there was that General Gordon, who was always thoughtful of everyone, asked that some motherly European woman might meet the refugees when they first arrived in Egypt, because there were many of the women who had never been in Egypt proper before.

The whole of these arrangements worked admirably, until 2,600 refugees had reached me at Assouan, and were distributed to their new homes. Many more than reached us were telegraphed as having left Khartoum, and we were afraid something was wrong; but at last we found that General Gordon, himself getting alarmed at the signs round Khartoum, had sent for all the soldiers who had been despatched, and who seemed in any way capable of bearing arms, so that only the sick, the old, and the maimed, and the women and children, reached Korosko and Assouan. The Arab is very different from us Western people in his love for his home and his village; it is a sort of religious worship, more than mere affection. He has very little of that love of adventure which makes us enjoy changing our place of residence or our country; he is a wretched creature if he is taken away from his village; he thinks Allah placed him there, and that it is a punishment to be taken away. Often and often, when I asked them at Assouan where there homes were, and where they wished me to send them, their answer was that they did not care, and that they would leave it to me to send them where I liked. I am not aware of more than a single death having occurred on the whole of that long, weary march; and this speaks highly for the admirable arrangements made by General Gordon. I always think it is well that we should bear in mind when we think of that life, which seems to have been sacrificed for nothing, that, had it not been for him, those 2,600 other lives might have been sacrificed too.

When Cuzzi telegraphed to me that there was no more news coming from General Gordon, I had to communicate with Cairo. In the mean-

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time as I had only two battalions, and a certain number of garrison gunners with some siege guns, they sent me three more Egyptian battalions and two camel batteries, and a short time afterwards they sent an Egyptian cavalry Regiment; so that we had a fair force at Assouan. It was then necessary to push troops south to Korosko and Wady Halfa. There was a sort of buffer province between the Soudan and Egypt, called Dongola, governed by a man of distinct character and ability, and with a reputation for religion second only to that of the Mahdi himself. He kept reporting that he was constantly defeating the Mahdi's troops, and claiming credit for these successes, and asking for much in return. There was doubt whether his statements were true; at the same time it was important to keep him friendly to Egypt. There is no doubt that he looked upon the Mahdi with contempt, and always refused to believe that any Mahdi could come who was black, or that any Mahdi could come from any place except the East—that is, from Mecca. There was some doubt whether he was not intriguing; however, I was ordered to send him a thousand rifles as a present. Before the escort coming from Dongola for the rifles reached Wady Halfa, the people at Cairo changed their minds, and telegraphed that I was not to give the rifles up. The escort tried to take them by force, but we re-captured them, and hardly had we done so before another message came from Cairo that we were to give them up again. This was the vacillating policy which was so frequent and so trying to any one who was performing executive duties.

However, we commenced the fortification of this place, and of Korosko (which is a very important one, on account of all the roads that come in there) availing ourselves at Wady Halfa of the buildings which existed in the place, which had been intended to be a terminus for the railway which the late Khedive had resolved on making to Khartoum, but he only got 32 miles towards Khartoum before the money gave out. It is a large, open plain, quite easy to defend, because the enemy would be under fire for a great distance. The friendly Arabs had been in the meantime bringing in word to me that there was danger of an advance from the East, on the opposite bank of the river to that on which the roads came out near to Assouan. On my reporting this to Cairo, they sent two English regiments, the Duke of Cornwall's Light Infantry to Keneh, and the Sussex Regiment to Assiout. One day a friendly Arab rode in in hot haste, and said that he had just heard that Berber had fallen, and that 4000 people had been killed. There was a great treasure-chest at Berber, and the Governor of Berber, Hassan Khalifa Pasha, was considered to be rather doubtful in his loyalty—like the Vicar of Bray, he leaned to whichever side was in power—and apparently the Mahdi had influenced him, and it was believed that he had betrayed his trust. As I was in my tent that night I heard a most extraordinary noise in the town. It was a bright moonlight night, and looking down the hill I saw the citizens flinging dust on their heads, and weeping and wailing loudly. I enquired the cause, and I learned that a thousand of the relatives of the natives of the people of Assouan were known to have been in Berber when it was alleged to have been taken, and these were the

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lamentations for those who were supposed to have been killed. The next day the leading sheikhs of the town came to me and asked permission to send all the women and children to Cairo, as they were afraid. I assured them that there was nothing to fear, and I put extra outposts round the town, under English officers, to re-assure the inhabitants. But in the meantime I telegraphed, with some reluctance, that I thought the time had now arrived for an English regiment to be sent up to me, and so the Sussex regiment was moved from Assiout to Assouan. It is curious to notice that in the third year of the first French Republic a French Brigade had reached as far south as that, and on the walls of a small temple were inscribed the names of the officers of this part of the army of Napoleon. The march of the English regiment through the bazaar with fixed bayonets had a very reassuring effect upon the people, who, being purely commercial people, were not apparently ashamed of showing fear; and amongst them were many Christian Arabs or Kopts, who had reason to fear the incursion of a strong body of Arabs from the south. I then moved on to Wady Halfa, until the expedition for which we all hoped should arrive.

Various rumours reached us perpetually from Khartoum, but none of such accuracy that we could rely upon them. The country is remarkable for rumours, the air is rife with them, and the longer you live there, the more necessary you find it to analyze the rumours that you receive with a wholesome criticism.

I think it was in the month of August, 1884, that the General of the line of communications arrived at Wady Halfa, and that the work of the new expedition may be said to have commenced. It was, I suppose, the most extraordinarily polyglot expedition that has ever been seen, for its size. We had Scotch, English, and Irish regiments, we had Canadian *voyageurs*, French, English, and Indian, we had Hindoos from India to work upon the railway, Kroomen from the West Coast of Africa for the boats, and we had Egyptians, Turks, and Soudanese—altogether, the most motley army, and, I suppose, the most admirably conducted expedition in history.

It was decided to adopt the course of the Nile, and (this of course, I can only say from what I had heard) I believe it was intended that the whole expedition should go by water, and there was no idea at first of crossing the desert to Metemneh, as one column ultimately did. The method of conveyance was to be in boats made on the system of the American whalers, and these boats were known during the expedition as the Nile boats. They were built to carry provisions for nine men for a hundred days, those provisions not to be touched till the boats reached Dongola; so that the army would then have in hand, practically, three months' provisions, which was considered enough for the completion of the expedition. It was not right or wise to depend at all upon the district for food, for the supplies are not much more than are required for the people themselves.[1]

[1] The necessities of the Egyptian troops which had been under my command during the previous six months had led to large accumulations of biscuit, beans, and forage at Wady Halfa on which the English commissariat drew frequently with great advantage.

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The chief duties at Wady Halfa were pushing forward the troops, and provisions and other stores, and it may give you an idea of what it was to be at the neck of the bottle—so to speak—as *we* were at Wady Halfa, when I tell you what was the ordinary day's work of a Commandant on the line of communications. At five o'clock in the morning he got up and visited all the camp; at about eight o'clock all the Egyptian work had to be done, both military and civil; at nine o'clock or soon after, all the Heads of Departments met, and every telegram which had been received from the north or the south during the previous day (not being of a confidential description) was read out, handed to the Head of the Department concerned, and acted upon by him, and then returned. Sometimes I had as many as some scores of telegrams in a day from north and south, and perhaps I had to send as many; so you may imagine what it is to be, as I say, in the neck of the bottle. Then he had to look out for the arrival of boats, with either troops or stores, and for their departure by rail or camel. He had to see that on the railway, which had been ultimately extended from 32 to 100 miles from Wady Halfa, people were constantly kept at work, and that food and water were constantly sent out to the rail-head. He had to attend, of course, to his duties in connection with the English garrison, look after a very large hospital, and, in fact, when night came, what with telegraphing and receiving telegrams all day, and riding about, sometimes also going out himself to the rail-head, he was quite ready to go to bed.[1] The same work, of course, had to be done by other station Commandants on the line, only differing in degree.

The Commandant is a sort of staff-officer; that is to say, a senior officer who comes into the station cannot interfere with the discipline or duties of the station; if he could, there would be no uniformity or system whatever; and even if, as was sometimes the case in a small station, a Subaltern was in command, he was the channel of communication to senior officers from the Commander-in-Chief.

The getting up of the boats was a work of great labour, because the river was continually falling, and, in fact, towards the end, we had to send many of the boats round the cataract on the train. There was a sort of small dockyard for these Nile boats at a place called Gemai, a little south of Wady Halfa, where they were all finally looked to before starting on their voyage to the south. The 2nd Cataract there became quite impassable before the whole of the expedition had gone on. When I first went there, a steamer was towed up, and afterwards another, an immense number of peasantry being employed to help to pull them up by ropes and tackles. One open flat-bottomed boat with stern-wheel, was taken up in pieces, and put together above the cataract. If that had not been done, the subsequent difficulties would have been much increased, for that was the only steamer left to run from Korti down to Abu Fatmeh. We had a similar one below the 2nd Cataract, called the *Water Lily*, which used to carry the post bags. There were

[1] A most elaborate diary had to be kept, and a copy sent to the Head-quarters of the Line of Communications, showing daily arrivals and departures, number of sick and deaths, state of provisions, coals, &c., train service, &c.

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a few old steamers on the Nile, which were used for towing, and we had several small steamers armed with Gardner guns, and worked by English blue-jackets, flying up and down the river.

When the expedition got to Dongola, it was then advanced to Korti, which became the head quarters of the army. When you get a line of communications of that length, ultimately 1500 miles long, you can imagine how great the risk is of having a weak link somewhere. Let us analyse, for example, how the medical wants were attended to. I do not believe the sick were ever better attended to in any campaign, or that any body of men could have worked with greater devotion and energy than did the officers of the Medical Staff on this Expedition.

The system in a war like this is to keep the fighting line clear of useless mouths; the sick and wounded must be got to the rear as fast as possible, because the food and transport at the front is required for those who can fight. There are field hospitals, advanced base hospitals, and a great base hospital. The system was, that cases which seemed likely to be cured very rapidly, were treated in field hospitals, or the more advanced base hospitals, and those likely to get well within three months were treated at Wady Halfa; if they did not seem likely to get well within three months, they were sent back to Cairo, which was the great base hospital. The comforts which were sent forward for the sick all along the line were, I might almost say, lavish in quantity, and required much of our transport: and certainly no other department was allowed to interfere with the Medical Department in the sending forward of those comforts.[1]

The Commissariat Department had incessant work, because so very little food and so very little forage could be got up the country, and the transport was at first quite inadequate for it. It ended ultimately in my being allowed to hire camels to any extent I could at Wady Halfa, to send forward to Dongola all the stores that were required, and the system worked very well. We took a receipt from the sheikh of the camels, which bound him; and we never found that any complaint arose. There was far less complaint as to the stores carried on the west bank by the hired Arabs than there was as to those carried on the east bank by our own organized means of transport. We found at first that the Greek merchants were quite beating us in the prices that they gave for hired camels, and that they repaid themselves by the enormous prices which they charged for their stores at Dongola;[2] so that we had to come to a sort of compromise.

The Ordnance Store Department also worked well. At first only two officers arrived; ultimately there were seventeen. The stores they supplied were excellent; in fact, at some of the stations as far north as Wady Halfa and Assouan, we were as well off for ordnance stores as if we had been at Woolwich.

The expedition was ultimately divided into two, and the great crisis

[1] The individual energy of the Medical Officers showed itself greatly in conducting the sick convoys to Wady Halfa from the south.

[2] Excellent work was done by camels sent down to me from Dongola by the Chief of the Staff, and carrying back stores from Halfa by the west bank. The strain was at times very great, but on the whole the wants of the army along the line were well met.

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occurred after that. General Earle's force, which consisted of the Royal Highlanders, the Gordon Highlanders, the Duke of Cornwall's Light Infantry, the Stafford Regiment, and some Egyptian Camel Corps and Egyptian Artillery, went towards Abou-hamed. At Korosko a large number of camels had been concentrated to carry stores to Abou-hamed for General Earle's force. The column had been carefully watched—so to speak—through the telegraph and special messengers as it advanced; the camels were actually laden, ready to start; but the news of Gordon's death arrived before the column reached Abou-hamed; and the column was re-called. I speak subject to correction, because I see one officer here who was there himself, but one of my officers told me that they were so near that they could see the desert round Abou-hamed from the high ground before they turned. They fought one battle, as you remember, at Kerbekan, and they destroyed the houses where the murderers of Colonel Stewart with their companions were supposed to have lived, and then, after their recall, the troops were scattered along the line in summer quarters—inverting the old European system—at Merawi, at Debbeh, and other similar stations on the line of communications.

The column which was to cross to Khartoum was to go to a place called Metemneh, and then, availing themselves of the steamers which Gordon had sent down, Sir Charles Wilson and his escort were to go to Khartoum with, I fancy, sealed instructions; but before they reached Khartoum, or just within sight of it, there was news (which was confirmed) that Gordon had been killed and the place had fallen.[1]

For many weeks, almost for months, doubts were thrown upon the fact of Gordon having been killed; it was said that he had been taken away a prisoner, that he was living in a convent, that he was in the castle; but when the subsequent evacuation took place, many people came down who knew perfectly well about his death, amongst others, three Egyptian officers who had been prisoners in Khartoum, and who told me separately, without any collusion, that their hands were tied behind their back, and that they were led out and saw Gordon lying on his face dead, in front of the house where he used to live. As they looked, this was said to them:—"There is your Pasha; what do you think of him now?" There seems therefore not to be the slightest doubt as to his death.

You can imagine what the shock to us was when the news came of his death. It was a blow that was felt by every one. The look on every private soldier's face was as if he had lost a dear friend. It was such a terrible end of all our labours, like a woman, after all her travail, being brought to bed of a dead child. A little hope was given us afterwards of the expedition being resumed later in the year, and that to a certain extent cheered the men; but it soon vanished, and orders came that a withdrawal was to take place, not merely of the English troops, but also of the inhabitants of Dongola.

The evacuation by the army was one of the most perfectly managed

[1] This column had fought two actions, and lost many gallant officers and men, before they reached the Nile near Metemneh, and Sir Charles Wilson started on the last stage of his journey.

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things in history; the whole thing worked like a clock. The Chief of the Staff at Korti telegraphed that he would be able to place 2000 men at my station every week, and that he thought I could only get 1500 away in the boats at my disposal. I was therefore ordered to build huts to accommodate the surplus. I consulted with the senior naval officer whom I had there, and with the naval transport officer. I built the huts, but owing to the remarkable energy of the two officers referred to, as fast as the men came in we put them on board the boats and sent them away.[1] The river was very low, and there were banks of mud forming, which made it impossible for steamers to go the whole way to Assouan; so we dâked the river into four dâks, and as the barges could float over the banks, they were cast off, and then were picked up by the next steamer. As fast as the train brought in a body of men to Wady Halfa from the south, they found the boats ready, they were put on board, provisions were issued, and they were sent forward. To do that implied an amount of energy and punctuality all along the line which it is impossible to praise too highly, because at the other stations there were not the advantages that we had at the large stations; and yet there never was a hitch. There was extraordinary perfection all along the line, and from every corps that came in there were reports of the extreme kindness and ability of the responsible officers on the Line of Communications.

The last to come in was General Brackenbury's column. The camel battery of the Royal Artillery, came in half batteries, escorted by Cavalry. These mounted troops came by route from Akasheh to Wady Halfa, away from the river, and we had to have water and food placed at various stations created in the desert, under a guard. Frequently I had a sort of nightmare lest the water had not got there, or had been looted by the Arabs; and I was very thankful when the last of the mounted troops arrived at Wady Halfa.[2]

The head quarters of the Line of Communication had been by this time brought in to Abri, and ultimately to Wady Halfa, which became the southernmost point that was to be occupied. Circumstances altered that again, and, as you know, at the battle of Ginnis after this expedition was over, the troops were considerably south of Halfa again. But it seems to be pretty well settled now that Wady Halfa is to be the southernmost point defended by the Egyptian Government, or by the Egyptian Government assisted by the English. Personally, as a matter of policy, having talked to the people and lived there, I think this a great mistake. I think that if you had to give up Khartoum, as was decided, the next best strategic point to hold is Berber, because that commands the road to Suakin as well as to Upper Egypt. Failing that, I cannot see why the province of Dongola should not have been held, especially as occupied by friendly people. It might have been held, and the *mudir* or his successor subsidized, the subsidy to be paid only while there was peace upon the frontier. Had

[1] Except when orders were given to keep certain troops at Halfa for a certain time, or a special purpose, as was the case with the Mounted Infantry, boats were always ready, and the huts were not required.

[2] The Egyptian camel batteries marched by the west bank from Dongola to Halfa, receiving a fresh supply of food and forage from my stores at Sarras, 32 miles south of Halfa.

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that been done, I feel very little doubt that peace might ultimately have been secured. The Bedouin tribes lived entirely by the carrying of produce from Khartoum and the south to Egypt, and of stores in return; the hire of their camels was what they lived upon, in the same way as the people who owned the boats on the river in Upper Egypt lived almost entirely upon the hire of those boats for the carriage of gum and spices and ivory and the like from the south, and return stores from Cairo to the south. For the moment there is not so much distress felt in Upper Egypt, because owing to the presence of English troops, and of a large Egyptian garrison, those boats are still frequently used. But when things resume their normal condition, I fear that the poverty in Upper Egypt will become something appalling. Just at the time Berber fell, the whole of the merchants of Assouan came to me with a petition that they might be relieved of taxation. At that time commerce had virtually ceased, and they showed me by their earnings and by the number of boats lying idle there, that they were suffering to an enormous extent, and that if the depression which had seized them extended and became more acute, it might ultimately mean the drying up of Upper Egypt. Upper Egypt is the place through which the stores of the south are transported northwards, and the stores of the north transported southwards. Put an end to that commerce, and you put an end to Upper Egypt; and that explains the hostility which has always been shown by the Government of Egypt to the scheme of a Berber and Suakin railway. Nature points to that line for getting the goods out of the Soudan, but Upper Egypt dies the moment you divert the traffic from the Nile to that railway; and although to a certain extent the world may complain and say that the making of more direct roads would be an advantage, I think the Governors of Egypt are entitled to be patriotic, and say,—"We are very sorry for the world, but we like Upper Egypt better." Although this has never been said in so many words to the promoters of that railway, that is, I imagine, really the reason why the Councillors of the Khedive of Egypt have always set their faces against the Suakin and Berber Railway; and I think it will be quite apparent to you that it is sound and just that they should do so.[1]

The expedition came down; the last regiment, the West Kent, was stationed at Wady Halfa, my duties were over, and I was able to come home. Eighteen months was a long time to have been up there, away from anything like the civilization of towns. I cannot describe the sensation of hearing wheels again on getting down to Cairo—we had heard no wheels up the country—there were no roads up there for wheeled traffic. But I was able to realize a good deal, the longer I remained at Cairo, which was re-assuring to anyone who had been interested, as I had, in Egypt and its people. I saw that undoubtedly reforms had been effected, and that much greater justice had been the result of the presence of the English in Egypt. The mists of intrigue were still, as ever, over Cairo, but I saw pleasanter relations growing up between the natives and ourselves, and I believe that the Nile Expedition did a good deal to encourage this kind of feeling,

[1] The making of that railway would probably also end in Suakin being made a free port—a material injury to the revenues of Egypt.

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for never did soldiers in another country than their own, behave better than our soldiers did towards the natives. There were 13,000 men, women and children sent down from Dongola when it was evacuated, to be distributed all through Egypt. We brought them down on the west bank, so as not to interfere with the movements of the army on the east bank; but there were many places, notably at Wady Halfa, where, if the soldiers had been disposed, they could have been rough, or insulting, or worse to the unfortunate women and children who came down from their old homes and were now homeless. I never once, to the best of my recollection, during the whole time of these 13,000 people passing through my hands, received a complaint against an English soldier from a refugee. That is something for us, who belong to the English army, to reflect upon with pride. There are temptations to which young soldiers are exposed, to which they often fall victims; they did not so in this Nile Expedition. Their conduct was admirable, although they were called upon to perform very singular duties. Often when the boats in going up the Nile got separated, a captain would find himself having to perform the duties of a private, or the private would have thrust upon him the responsibilities of a captain; and yet they never failed.

Everything that I witnessed in connection with the English army in the Nile Expedition, gave me greater pride than I had even had before in that profession to which I have for thirty years belonged. I think there is a more reasoning discipline among the men, which is doubtless born of better education, for the School Board has reached that class from which we get most of our recruits. The old iron and unbending discipline will not do now; we must have a discipline which appeals to the reasoning powers of the men. Once secure that form of discipline, and then officers and men work hand-in-hand. That discipline was greatly present in this Expedition, and looking upon the men who passed through my hands, I feel that any other expedition might go anywhere with perfect confidence, with such officers and men as we had in the Nile Expedition.

Whatever may be the future of Egypt, I believe the kindly relations established by the good conduct and justice of Englishmen will remain. The problem is a very difficult one; the future history of Egypt is a tangled skein; but there will always be in it a golden thread, telling traditions of English honour, of English justice, and of English courage.

Colonel E. Markham, *Director of Artillery Studies*.—Gentlemen, I think I only express the feelings of all here when I say that we have listened to this account of the Expedition on the Nile, which has been given to us by Colonel Duncan, with very great interest. He has collected a mass of information and detail, and given us in forty-five or fifty minutes that which would have taken us some hours to read in a book; and a great deal of it has been given most graphically, and some of it very amusingly. I think that Lord Wolseley, in selecting Colonel Duncan for the position of Commandant on the Line of Communication at Wady Halfa, must have seen that he had got a man of very great energy, and that he had put the right man in the right place (cheers); and I am very glad that his services there have been duly acknowledged and recognised. I have only to thank him again in your name for the very interesting lecture he has given us.

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THE
ATTACK FORMATION OF INFANTRY.

BY

LIEUT.-COLONEL G. B. MACDONELL, R.A.

THE time-worn recommendation of "Let the cobbler stick to his last" will perhaps be applied to me, as doubtless it has already been to many others, who, like me, have ventured to express opinions on subjects out of their immediate professional groove, and were it not that gunners pride themselves on being soldiers first and artillerymen afterwards, I would shrink from the discussion in these pages of a subject such as forms the heading of this paper. But being a soldier, and not feeling bound to confine myself to the limits of the particular branch of the great profession I belong to, I venture to make a few remarks and suggestions on a subject that must be vital and interesting to all. And now do so without further preface or apology.

Of the many proposals for the proper system of attack for Infantry we have most prominently before us the present system as laid down in the Drill Book, and one of home growth, namely, the "Fours-deep formation." The former bears traces of importation from foreign sources—it is none the worse for that—while the latter is a product of native indigenous thought. It is not my intention at present to criticise these systems at any great length, as they have been before the military public for some years past, and their merits and faults have been abundantly discussed by able tacticians. I will only use them to compare them very shortly with the modified plan of attack that I shall now endeavour to explain.

Beginning with the service system. The frontage of command for the directing officer is much too great for one man to direct or control. Although he may be assisted by zealous and efficient officers and N.-C. officers, the frontage of two hundred paces is too much for him to supervise in any case, and especially so in hilly broken country or bush, where the men will naturally stray to the right and left in order to avoid the difficult places, and collect in knots or groups in the hollows. There they will form an irregular column, if a crowd or small mob may deserve such a name; each man hindering his comrade in the proper use of his arms, and, collectively, causing a general check, during which there is the risk of annihilation from shrapnel, with the certainty of companies getting mixed up and out of hand. The appended sketch (Fig. 1) will show this tendency.

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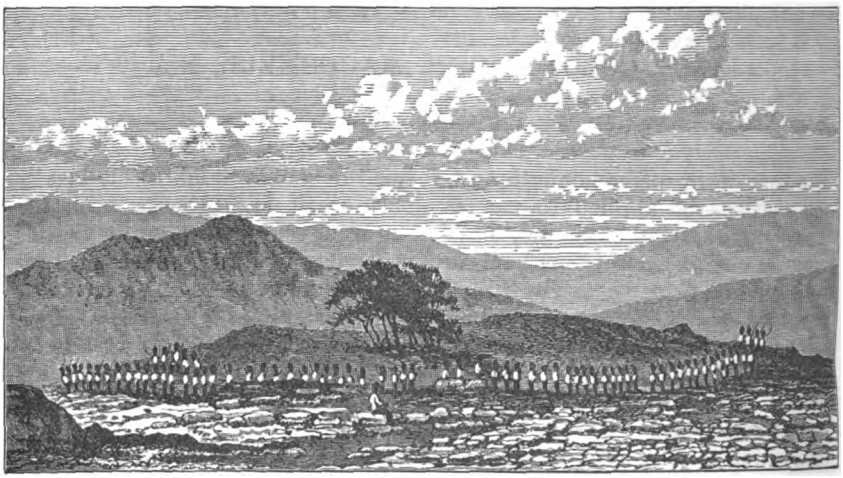
The remedy lies in limiting the front of command for the attacking companies, and thus ensuring their direct forward advance.

In the final stages when the advance *may* be made by the forward rush of alternate companies, it will be found most difficult to get the widely extended body of men to move in such a manner straight to the front that they will not drift away to the flanks, and mask the fire of the troops in rear.

FIG. 1.



Theoretically speaking, the soldier, as a fighting unit, should be interchangeable, and be expected to fight in any point of the firing line he may be drafted into. No doubt he will fight well, but this method of employing him is not the best. Human nature and sympathies must count for something: he will practically fight the best when he has his comrades of the barrack room, and bivouac side by side with him, and when under the officers he is accustomed to obey in every day life.

So when it comes to thickening the firing line by hurrying up supports, and even reserves, the men lose their company cohesion, and a certain amount of uncertainty takes the place of the confidence and homogeneity of feeling that should pervade the ranks. It may be assumed to be a mistake to mix up men of different companies who are strangers to each other, when a grand effort is being made which exacts the utmost of discipline and mutual confidence and support. An amount of hesitation will be introduced, new men and new commanders will appear on the scene, men of the fighting line will not know whom to obey, and this at a moment when to hesitate is to be lost, and success depends on the onward solid surging of the attacking masses.

The "Fours-deep formation" is pleasing from its very simplicity. The Battalion is at once broken up into its components of,—

Firing line. Supports. Main body.

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Its intention is to restrict the front of company command, and to feed the attack from the resources of the company itself.

But with all its simplicity there are grave objections to be found to this system.

First. There is an element of loose formation introduced from the commencement of the movement forward.

Second. The direction of the attack is not under sufficient control after the guides or bannerets may have been disposed of by the enemy.

Third. At the final stages of the attack a heavy concentrated fire cannot be maintained when the men drift into the firing line in thin films of skirmishers, and at the supreme moment, when victory or defeat hang in the balance, the reserve is too feeble to be of any great value in deciding the fight.

As an alternative to the plans I have glanced at above, I bring forward a proposal of my own, in which I advocate that the attack should be made, supported, and finally reinforced by the company itself. This plan does not differ from the former but in its details and the greater cohesion of its units.

The following may be assumed as being the principal requirements for a good system of Infantry attack *per company.*

1st. The formation of the firing line should be simple, readily assumed, the distance between individual units not too great, and the whole proportioned in numbers so as to be within the control of an officer.

2nd. The closed bodies in support must not afford too large a mark for aimed fire.

3rd. The firing must be close and well kept up from its commencement, and must increase in intensity as the position is approached, its greatest intensity being at the moment when the position is to be carried by the rush.

4th. The main body must be of sufficient strength to give this increased intensity of fire, and also to be able, in close formation, to give an almost column impetus to the rush.

5th. If the attack should fail, the troops should be able to withdraw, holding the enemy in check, and re-forming with as little delay and confusion as possible.

This last condition is perhaps the most difficult of all to fulfil, its successful completion will entirely depend on the *sang froid* of the officers, the discipline of the troops, and the amount or extent to which they are mixed up or in confusion.

By my plan the front of command per company would be so lessened that the personal influence and example of the officer in command would be felt all through his part of the firing line, while the danger of overlapping or masking adjacent companies would be lessened, and the thick chain of skirmishers who form the firing line will be more

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surely guided to the point of attack. In the heat of action, and amid the almost incessant roar of a breech-loader fire the voice cannot be heard at any great distance. I have had some experience of this some time ago, when in command of a brigade of volunteers, I found it impossible to regulate the fire: even when assisted by a large staff of officers of the regular army, our efforts to make ourselves heard only extended to a few paces to the right or left of our positions.

Before bringing my system forward, I would have liked to have noticed the continental plan of large companies, as it seems to me to be the readiest way of solving the difficulty, but since the consensus of high military opinion has pronounced itself strongly against its applicability to our British Army system, I will not discuss its advantages, but will proceed to explain the system I advocate for adoption.

I propose that the numerical strength of our companies should be increased to 128 men exclusive of sergeants and buglers. I would also exclude clerks, servants, bâtmen, &c., from the fighting strength, which, as I have said above, would consist of 128 rank and file N.-C.-officers and men.

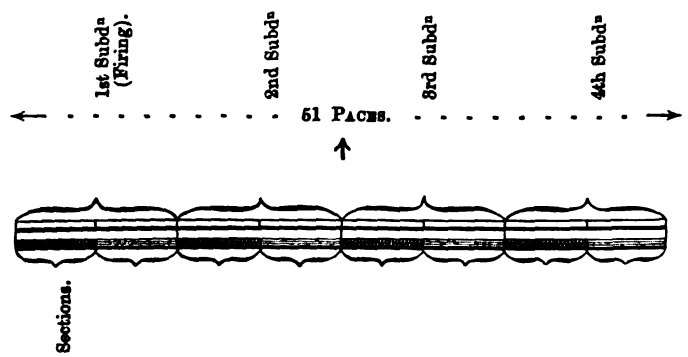
This company would be divided into—

4 subdivisions	of 16	files each.[1]
8 sections	of 8	,,
16 half sections	of 4	,,

A company of the above strength would be quite strong enough to be able to take care of itself when on detached duty, while its absence from the battalion would not (comparatively speaking) be a source of weakness to the latter.

FIG. 2.

A COMPANY OF 64 FILES IN LINE.



HALF SECTIONS ARE NOT SHOWN.

[1] One sub-division of selected good shots to form the firing sub-division. These men should be distinguished from the others by some badges other than those of marksmen, that would give them some social distinction, which would be an honour to gain, and the loss of it would be felt as a disgrace.

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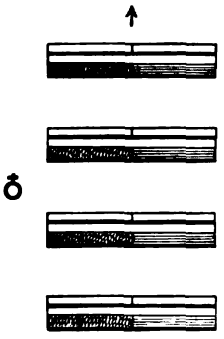
FIG. 3.

A COMPANY COLUMN.

THE PROPOSED PARADE AND MANŒUVRE FORMATION.



Eight of these companies on a war strength of 128 rank and file per company, would form a battalion of 1024 combatants under the command of a Lieut.-Colonel. Two of them would form a suitable command for a Major. The front of a company like the above would be 51 paces. The front of a company column; or column of subdivisions would be 12¾ paces. By this arrangement there will be a firing line of one sub-division or 32 men, sufficient as a command in frontal extent for one officer and two sergeants to control and direct. One sub-division or 32 men will form the support for this firing line. Two sub-divisions or 64 men equal in numbers to all in front will form the main body or reserve. The firing line of a company would, when extended, cover the whole front, the individual units being a little over 1½ paces from each other—measuring from the centre of each file.

It may be objected that in this *close* extension the men are separated at too small intervals, and that in thus placing them I defeat the advantages of the extended formation; but in my experience the closer one can get the men together, the better will be the work you can get out of them, and the more easily will they be guided and brought to the front.

The losses sustained by Infantry in an advance have been made too much of, and the examples that have been quoted are taken from cases where extended formation did not form a part of tactics. True, the Prussian Guards at St. Privat suffered enormously when, against all orders and regulations, they were made to advance in line of battalion columns against an unshaken enemy. The Russians at Plevna experienced a similar fate. After such striking and ghastly experience, attempts of a like nature will never be renewed: if they are, the results may be safely counted on beforehand.

The wasteful and unscientific system of firing a great number of random shots at a closed mass of assailants will be successful, *provided* the fire is kept up long enough, but would be ineffective against the undulating ever-advancing line of a modern firing line, which is in constant movement, and can retaliate by a three or four to one fire against the defenders of the position, when, in addition to this

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advantage of numerical superiority, the assailants have had the approach to the position simplified by a preparatory artillery fire, the apparent disadvantages of the attacking force disappear; the long range unaimed fire will lose its target, and the aimed fire at effective ranges will be met by something very far superior. In illustration of the very small loss that an extended line of Infantry can suffer, even under heavy fire, I will introduce an anecdote. During the Egyptian campaign of 1882, a certain battalion of a very distinguished regiment had, on the morning of one of the actions that preceded Tel-el-Kebir, 50,000 rounds of Martini-Henry ammunition served out, and when the fight was decided (it was at Kassasin Lock) every round was fired off and the battalion returned to camp without having accounted for a single man of the enemy, though they were in masses in front of them. I only quote this instance, as the facts were given to me by the officers of the battalion. No doubt some of the enemy were hit, but after all this expenditure of ball cartridge none of them were left behind. This failure may be accounted for by the presence in the ranks of so many of the so-called Army reserve, most of whom had not fired a rifle for many years back.[1]

When shooting at a target or enemy, men are not all equal in marksmanship; in this, as in every other pursuit, amusement or sport, there is a certain level that divides the few proficients from the great multitude of mediocrity. Thus, men may be good cricketers, racquet or billiard players, or shots at game, but there is a certain point of excellence beyond which the diligent practice of a lifetime will not advance them. It is the same in rifle shooting, some men, whether from defective vision, nervous temperament, or, even as some say, from the colour of their eyes, can never attain excellence as rifle shots at long ranges. The army contains a great many so handicapped, and taking this into consideration, it will be well to prepare the company beforehand, so that all the marksmen and fair long range shots should be assembled in the firing sub-division that will commence every action; these will form the hard polished head of the spear, so to speak, while the inferior shots, all good stalwart men in their way, may be trusted to form the supporting masses that will be brought into action at the final phases of the attack. This system of selection would create a spirit of emulation in the companies, and make it the ambition of every soldier to try his utmost to qualify himself for admission into the *corps d'elite* of the company; numbers will fail to come up to the standard of excellence, but the desire to qualify will doubtless benefit the general shootiug efficiency of the whole body.

A battalion of eight companies of the strength I have proposed would give a fighting effective of 256 chosen riflemen to commence the attack with, and cover its advance to decisive ranges.

The Drill Book, and also some tactical handbooks, lay down that the extension of Infantry for attacks should take place at a distance of

[1] It is a pity that these men cannot be assembled yearly at the District Regimental Depôts, and put through a short musketry course. Failing this, they ought to be Militiamen or effective Volunteers.

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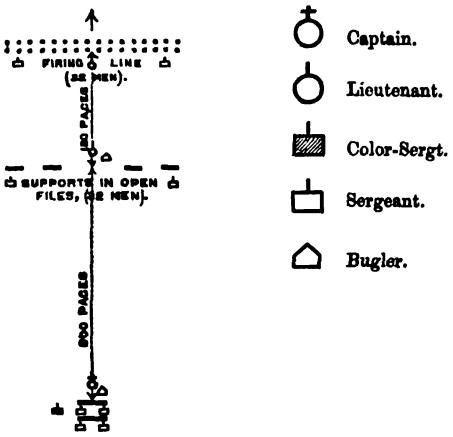
2000 yards from the enemy's position; this, no doubt, is most necessary if the attacking force appears on the field of action in large close battalion masses, but with the small frontage of the company columns of attack (each being only 10⅔ yards) the mark they would present to an enemy would be so small that an advance in close formation could safely be undertaken until such a distance was reached, when the mark so visually widened, that aimed fire could be directed on it with some precision. If even a short distance of say 400 yards could be quickly got over in this formation there would be a great saving of time, and the direction and the cohesion of the men controlled and retained with less trouble. Of course, from the nature of the organization, frontal extension into a firing line, and the lengthening out of the company column into its parts of supports and main body can be carried out at any time[1] when circumstances demand the necessity of such a step.

The general idea of an attack carried out on this system is that after the preliminary artillery duel, when the hostile guns have been sufficiently crippled, the attacking Infantry will emerge from the cover under which they have remained sheltered, and appear as a line of company columns at deploying intervals supported at due distance by the second line. These will proceed at a rapid pace until the necessity of frontal extension occurs, when the firing sub-divisions of companies will extend and form a continuous firing line with the usual intervals between the companies, the supports and main bodies will remain halted, lying down, and move on when they have obtained the necessary distance from the front.

FIG. 4.

COMPANY COLUMN OF ATTACK.

1ST STAGE.



MAIN BODY (64 MEN).

[1] It must be kept in mind that there is a very considerable difference between the magnitude of objects freely seen and those viewed through a scale. The apparent magnitude of an object is much greater than the measured one. The visual aspect of the front of one of these company columns, when distant 2000 yards from the eye of the observer, is so minute that it would be most difficult to direct fire on it with any degree of precision.

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A battalion would then have,—

In firing line	...	...	256 rifles.
In support ...	...	...	256 „
Main body ...	...	...	512 „

I am not an advocate of the so-called *open* drill system, which I think is a fallacy, *open* drill will soon degenerate into *loose* drill. The openness will exhibit itself spontaneously, even with drilled troops, in a most unpleasant and undesirable manner at times when least wished, and if taught in peace time will break out in an exaggerated form when the men are under fire and less easily held under control. It may in the course of an action lead to a series of brilliant hand-to-hand combats, but these, interestingthough they may be in the gymnasium, are useless in warfare, where success depends on the combined effort of the masses.

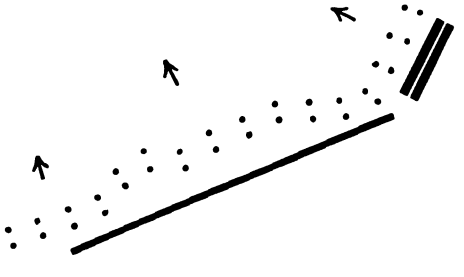
I regret that the means at my disposal have been insufficient to enable me to make any large experiments on the subject I have endeavoured to put forward. What I have written has been deduced from observations made on a single company, but the action of a battalion is only that of so many such companies acting in accord: but I hope that some officers of the regular or auxiliary forces will, when they have an opportunity, give my system the benefit of a trial.

The company main body considered as such will, in ordinary cases, be under the orders of the company commander, and be held as a reinforcement to its own fighting line and supports in front: but circumstances may happen when it may be necessary to concentrate all the company main bodies of the battalion to act in a mass under the Lieut.-Colonel, and from the weight of fire and numbers force a weak point in the hostile position. All or portions of the company main bodies can easily be employed for this purpose, without losing their company individuality, and be launched at the weak point of the defensive line, which an observant Commander will not fail to detect during the advance.

FIG. 5.

COMPANY COLUMN OF ATTACK.

FINAL STAGE.



The arrival of such a compact body, of comparatively fresh combatants, at the point of attack will have most powerful influence in deciding the issue of the action.

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I know I have been too prolix in enunciating my plan, and now before closing, will sum up the whole in claiming the following advantages:—

1. The advance can be made in a manageable formation, and with diminished risk.

2. The company columns can, at any period of the advance, be transformed into attack formations with great rapidity.

3. The firing line is thick, strong and flexible, well under command at all times, and furnishes an abundance of fire without an undue crowding of the men.

4. The men are brought up into the firing line without the liability of being mixed up with those of adjacent companies.

5. The blow of the shock is very heavy, as masses of men and fire can be brought into the vital parts of the enemy's position.

6. If the attack should be unsuccessful the retreat can be made with order.

Finally, as the whole system is based as a starting point on the old fashioned shoulder to shoulder drill, the tactical changes requisite for the difference between civilized and savage warfare require no peculiar or particular instruction for the troops.

LEITH FORT,
30th October, 1886.

P.S.—In order to avoid any misapprehension of the nature of the scheme as set forth in the foregoing paper, I wish to state that it will not involve any plan for the augmentation of the Infantry of the Line in peace time.

For instructional purposes the present small companies will have to be amalgamated on parade so as to obtain a sufficient numerical strength. On mobilization the large war companies will be formed by drafting men from the territorial reserves into the ranks of the companies on the peace strength.

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FIELD SHRAPNEL FIRE.

BY

MR. A. G. HADCOCK, R.A.,

INSPECTOR OF ORDNANCE MACHINERY.

THE valuable paper on "Shrapnel Fire," by Major Nicholson, R.A.,—*R.A.I. Proceedings*, Vol. X., p. 173—appears to have excited a good deal of interest in most of the European countries.

In France and Italy tables already exist (*Revue d'Artillerie*, December, 1885, and *Revista di Artiglieria e Genio*, November, 1885) for obtaining the probable destructive effects of the bullets in shrapnel shells; and it is now proposed to calculate similar tables for the shells of field guns, so as to give, at a glance, the probable area covered at different ranges and positions of burst.

It must not be expected that the actual results obtained by calculation will be anything more than approximate to those obtained in practice, as so many vital conditions, such as the humidity of the air, height of barometer, temperature, &c., may differ considerably on two successive days. The calculated results will be the mean of those obtained by practice.

1. Lieut.-Colonel Hawkins (late Captain Instructor, Royal Laboratory), considers that shrapnel bullets would not be effective unless they have a greater striking velocity than 400 f.s.

The velocity at which a bullet would be effective would of course depend on its weight and diameter, as the buckshot in the 2·5-inch shell could hardly be expected to be so destructive as a bullet of 18 per lb., supposing they both had the same striking velocity. It will be best to take the minimum effective velocity at 400 f.s., for comparison, as no other data exist.

The table by which the velocities, distances covered and angles of descent were obtained, was calculated for a minimum velocity of 300 f.s.; so that if the velocity falls much below this, the results given in Table I. must be taken as only approximate.

In the case of the 12-pr. steel shell this specially applies, as the velocity falls a good deal below 300 f.s., also in both the cast-iron and steel shells of the 13-pr., and in the 2·5-in. shell it applies to a less extent.

It will, perhaps, be as well to give the number and weight of the bullets in the different types of Field Shrapnel.

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In the steel shrapnel, the—

2·5-inch R.M.L., Mark III., has 100 of 35 per lb., 11 buckshot of 220 per lb.
12-pr. B.L., Mark I., 177 of 35 per lb.
13-pr. R.M.L., Mark II., 133 of 34 per lb.

The shells containing bullets of 35 per lb. are of Armstrong manufacture; the Royal Laboratory use bullets of 34 per lb.

In the cast-iron shells, the—

7-pr. 200 lbs. R.M.L., Mark VII., has 21 of 18 per lb., and 21 of 34 per lb.
9-pr. R.M.L., Mark VIII., 28 of 18 per lb. and 35 of 34 per lb.
13-pr. R.M.L., Mark I., 116 of 34 per lb.
16-pr. R.M.L., Mark III., 72 of 18 per lb. and 56 of 84 per lb.

2. The results obtained will first be given in Table I., and the method of calculation afterwards; it will be sufficient to say for the present that Bashforth's method has been used for the calculation of the trajectories of the shell before bursting, and Niven's method for those of the bullets after burst.

The ranges have been taken from 500 yards to 4000 yards, increasing by increments of 500 yards; but it is quite evident from the Table that in the case of the 9-pr., 13-pr. and 16-pr. the range might be considerably increased.

At each range the shell is supposed to be burst either 50 yards or 100 yards short, and the Table gives the length X in feet of the major axis of the ellipse which the ground makes with the cone of dispersion, the angle of descent, β, and the lowest final velocity, v. where this is greater than 300 f.s. The angle of descent given is due to that bullet which travels furthest from the point of burst. This bullet also has the lowest velocity.

3. The most important result in the Table is the comparison between the cast-iron and steel shells of the 13-pr., and between the shells of the 12-pr. and 13-pr. In the 12-pr. the lowest velocity is never so great as 400 f.s., so that a certain number of these bullets would probably be wasted at long ranges, while at short ranges the waste would be still greater, as the velocity of the bullets in the upper trajectory of the cone increases up to a certain point and then decreases.

The velocities of the bullets of the 16-pr. shell given in the Table are a good example of this. The velocities of the 12-pr. bullets attain their maximum at about the 4000 yards.

The velocity of the bullets at the time of burst is taken, in the cast-iron shells, to be that of the shell at the time of burst; for, although the bursting charge is in the base of the projectile, it has but little effect on the bullets, but exerts itself in breaking up the body.

In the 13-pr. steel shell the bursting charge is in the base and the bullets are blown out of the body, and receive an additional velocity of about 200 f.s.; but in the 12-pr. and 2·5-inch the charge is placed in the head of the shell, so that the body is drawn off the bullets like a glove and the bullets are retarded. Colonel Hawkins considers that this diminution of velocity would be about 200 f.s. in the 12-pr. shell, and 100 f.s. in the 2·5-inch at the moment of burst.

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TABLE I.

Range.	500 yards.						1000 yards.						1500 yards.						2000 yards.					
Shell burst short	50 yards.			100 yards.			50 yards.			100 yards.			50 yards.			100 yards.			50 yards.			100 yards.		
	X	v	β	X	v	β	X	v	β	X	v	β	X	v	β	X	v	β	X	v	β	X	v	β
			° ′			° ′			° ′			° ′			° ′			° ′			° ′			° ′
7-pr. ... Large bullets	1377	310	8 18	—	—	—	978	375	5 10	1100	330	7 20	498	475	3 43	748	363	6 25	305	485	5 26	500	408	7 40
7-pr. ... Small "	1365	—	10 0	—	—	—	1067	345	5 40	1110	—	8 20	571	440	4 23	873	348	6 40	358	445	5 40	548	380	8 0
2·5-inch Large "	1550	—	11 0	1583	—	13 0	1333	—	9 15	1392	—	11 30	1080	320	6 45	1162	—	9 15	858	353	5 28	959	310	8 6
2·5-inch Small "	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	807	—	—	—	—	—
9-pr. ... Large "	1540	345	6 55	1560	340	7 30	1201	390	5 12	1280	364	6 15	832	470	3 30	980	410	5 5	487	550	3 0	692	455	4 45
9-pr. ... Small "	1490	303	8 13	1500	300	8 28	1210	340	5 50	1265	320	8 56	894	410	3 50	1015	360	5 50	540	480	3 13	736	405	5 44
12-pr. steel shell	1900	—	20 0	—	—	—	1830	—	22 0	1870	—	24 0	1650	—	22 0	1780	—	25 0	1450	—	17 0	1560	—	22 30
13-pr. ... Steel shell	1729	—	10 10	—	—	—	1557	—	8 12	1585	—	10 20	1381	330	6 12	1400	320	7 50	1014	445	3 40	1160	355	6 15
13-pr. ... Cast-iron shell	1652	—	10 0	—	—	—	1413	320	7 0	1450	—	8 24	1196	360	6 15	1261	325	7 30	861	435	4 8	1125	360	8 9
16-pr. ... Large bullets	1550	340	6 50	1571	335	7 25	1287	370	6 0	1323	365	6 35	940	454	4 0	1045	407	5 0	572	540	3 40	768	450	4 35
16-pr. ... Small "	690	413	2 26	733	365	3 46	485	478	2 12	577	430	2 50	248	580	2 18	359	455	3 32	159	595	3 44	270	480	5 15

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TABLE I.—Continued.

Range.	2500 yards.						3000 yards.						3500 yards.						4000 yards.					
Shell burst short	50 yards			100 yards.			50 yards.			100 yards.			50 yards.			100 yards.			50 yards.			100 yards.		
	X	v	β	X	v	β	X	v	β	X	v	β	X	v	β	X	v	β	X	v	β	X	v	β
			° ′			° ′			° ′			° ′			° ′			° ′			° ′			° ′
7-pr. .. Large bullets...	192	475	9 24	365	400	10 56	150	445	14 45	286	378	16 10	133	408	20 45	265	346	21 33	—	—	—	—	—	—
7-pr. .. Small " ...	218	448	9 0	400	363	11 5	165	425	14 12	313	346	16 0	143	388	20 10	289	320	21 25	—	—	—	—	—	—
2·5-inch Large " ...	498	430	4 35	742	325	8 20	370	445	5 40	560	355	8 50	252	440	8 38	466	345	10 50	191	420	12 30	357	340	14 25
2·5-inch Small " ...	541	—	7 30	—	—	—	433	300	7 0	576	—	—	309	330	8 29	520	—	—	245	325	11 20	355	—	14 20
9-pr. .. Large " ...	296	578	4 35	530	470	6 0	195	582	7 23	388	475	8 12	157	554	10 22	304	470	11 0	133	520	14 5	250	450	15 0
9-pr. .. Small " ...	339	540	4 30	583	420	6 20	225	547	6 50	424	435	8 14	175	530	9 54	337	430	11 5	145	500	13 37	274	418	14 45
12-pr. steel shell	1210	—	12 0	1360	—	19 0	990	—	9 0	1143	—	16 0	756	315	7 10	969	—	14 0	560	338	7 16	753	—	12 30
13-pr. ... Steel shell	700	517	3 10	922	423	5 10	398	643	3 32	671	478	5 20	259	694	5 38	486	526	6 40	208	689	7 30	397	558	8 20
13-pr. ... Cast-iron shell	657	470	3 20	800	410	5 30	385	555	3 50	638	430	6 0	261	575	5 47	475	470	7 10	215	570	7 37	356	465	9 13
16-pr. ... Large bullets...	260	625	3 20	530	515	4 55	222	615	5 54	395	508	7 5	183	595	7 50	328	503	8 55	141	575	11 28	261	494	12 26
16-pr. ... Small " ...	120	611	5 42	210	472	6 44	88	595	8 30	160	468	9 20	79	570	10 38	141	460	11 30	65	545	14 40	118	436	15 30

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...culation of the minor axis of the ellipse of dispersion is ...difficult matter but geometry appears to offer more hope, and ... any rate give a fair approximation, the correctness of which ...es with the height of burst and therefore with the range.

...o do this, the cone of dispersion is taken to be a true circular cone ...nerated by straight lines, the position of the highest and lowest of ...hich are known, since they pass through the point of burst, and the ...nds of the major axis found by calculation. If these are measured ...ff to scale the minor axis can easily be found by orthographic ...rojection.

As examples the minor axis has been found in this manner for two ranges, viz., 2000 yards and 4000 yards, supposing the shell burst 50 yards short. In the case of the 7-pr. the ranges are 2000 yards and 3500 yards, as at 4000 yards the bullets are ineffective. Should the minor axis be required for any range between these it can be obtained by proportion, and if the burst takes place 100 yards short the minor axis can be doubled.

7-pr.	Large bullets	at 2000 yds. range 35 ft.,	at 3500 yds. range 62 ft.
	Small	42 "	69 "
2·5-in.	Large	45 "	4000 yds. 61 "
	Small	53 "	73 "
9-pr.	Large	36 "	44 "
	Small	31 "	48 "
12-pr.	Steel shell	66 "	182 "
13-pr.	Steel shell	45 "	44 "
	Cast-iron shell	44 "	45 "
16-pr.	Large bullets	36 "	40 "
	Small	15 "	20 "

These results will be found to agree fairly well with those obtained in practice by Major Nicholson.

The velocity of the bullets in a shell, due to rotation, is proportional to their distance from the centre of rotation, so that for the same gun the bullets in a steel shell with bursting charge in the base have a greater velocity than those in a cast-iron shell, as the material of the body of the former is thinner than that of the latter. A steel shell consequently spreads the fire more than a cast-iron one and contains more bullets, but were it not for the action of the bursting charge in increasing their velocity, it would probably be much less effective.

5. The question as to whether the bursting charge should be placed in the base or head of the projectile appears to be a somewhat serious one. There are advantages in both cases. If it is in the base the shell is more expensive and contains fewer bullets than when it is placed in the head; but the bullets in the former case have a much higher velocity than in the latter, and are probably more effective, for although they are arranged round a central tube and therefore the the centre of the ground covered would have no direct hits, yet any object of about a man's height in this space would probably be struck by a bullet ricochetting or by a direct hit above the ground line, as

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the angle of descent of the upper half of the cone is generall
When the charge is placed in the head, the whole of the int
the shell is filled with bullets, so that the whole of the gr
covered by direct hits; but the velocity of the bullets is so
reduced by the effect of the charge on bursting that it is dou
whether a great number of them would be effective.

Take for instance an example in the 12-pr. In bursting the sh
50 yards short at 3500 yards range the final velocity of the bull
travelling the greatest distance from the point of burst is 315 f.s
and the velocity of the axial bullet, *i.e.*, that bullet in the shell whic
has no tangential motion, and whose trajectory therefore forms the
axis of the cone of dispersion, is 540 f.s. These two bullets reach
the ground 674 feet apart.

Now, supposing the velocity of the bullets as they reach the ground
to vary as their distance from where the axial bullet strikes the ground,
which would be very nearly correct, we can find at what part of the
ground a bullet would have a velocity of 400 f. s. This is found to be
420 feet from where the axial bullet strikes the ground, so that 254
feet of the major axis of the ellipse of dispersion is covered by an
ineffectual fire only. Whereas, in the steel shell of the 13-pr. at the
same range and distance of burst, all the bullets will be effective.

The following table gives the distances between where the axial
bullet and the bullet travelling in the upper trajectory of the cone
strike the ground in column x, the final velocity of the axial bullet in
column V, and the length of the major axis of the ellipse of dispersion
covered by ineffectual fire in column I, it being understood that for a
bullet to be effective it must have a velocity of 400 f.s.

The buckshot and cast-iron segments in the 2·5-inch will not be
taken into account, as the buckshot would hardly be effective in
comparison with other bullets, and it is hardly possible to calculate the
trajectory of a segment.

6. It will be seen that the length of the major axis of the ellipse of
dispersion diminishes as the range increases, so that for short ranges
it is much greater than for long ranges. In the short ranges half the
bullets in the shell travel off with a certain amount of elevation, due
to the angle of descent of the shell at the time of burst being less
than half the angle of the cone of dispersion.

In most of the shells there are two sizes of bullets, so that there will
be two distinct ellipses of dispersion superposed on each other, the
centres of which may generally be taken as coincident.

In the Italian paper, "Sul Tiro a Shrapnel,"—*Rivista di Artiglieria
e Genio*, Nov. 1885, quoted above, the number of bullets per square metre
is given as though they were uniformly spread over the ellipse of dis-
persion. This, of course, is not the case, as in that part of the ellipse
nearest the point of burst the bullets will be crowded together, while
they will spread out as they travel further, so that the number of
bullets per square foot varies considerably. This only applies to
direct hits, as the number of points struck by the bullets ricochetting
would vary with the hardness of the ground.

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TABLE II.

Range.		500 yards.			1000 yards.			1500 yards.			2000 yards.			2500 yards.			3000 yards.			3500 yards.			4000 yards.		
		x	*V*	*I*	*x*	*V*	*I*	*x*	*V*	*I*	*x*	*V*	*I*	*x*	*V*	*I*	*x*	*V*	*I*	*x*	*V*	*I*	*x*	*V*	*I*
7-pr. ...	Large bullets...	1271	775	246	890	698	69	426	635	*e*	242	580	*e*	139	520	*e*	99	474	*e*	83	420	*e*	—	380	*i*
	Small " ...	1260	752	—	977	682	159	495	621	*e*	289	570	*e*	161	513	*e*	113	463	*e*	91	416	39	—	373	*i*
2·5-inch	Large " ..	1424	924	—	1227	820	—	986	730	192	773	665	116	425	608	*e*	302	560	*e*	192	522	*e*	136	468	*e*
	Small " ...	—	790	—	—	708	—	—	646	—	717	596	—	475	541	—	361	502	178	242	464	126	183	426	136
9-pr. ...	Large " ...	1421	978	123	1101	878	22	746	810	*e*	416	750	*e*	232	690	*e*	139	640	*e*	105	610	*e*	84	570	*e*
	Small " ...	1374	950	206	1105	855	129	805	790	*e*	504	732	*e*	271	675	*e*	166	628	*e*	121	585	*e*	96	545	*e*
12-pr. steel shell		1764	1005	—	1705	890	—	1539	780	—	1346	695	—	1114	636	—	901	584	—	674	540	254	482	493	193
13-pr. ...	Steel shell	1597	1240	—	1437	1090	—	1280	1005	132	928	953	*e*	620	910	*e*	329	870	*e*	201	840	*e*	151	810	*e*
	Cast-iron shell	1519	1110	—	1302	960	162	1105	870	86	781	830	*e*	579	770	*e*	320	730	*e*	202	690	*e*	159	650	*e*
16-pr. ...	Large bullets..	1427	995	130	1186	900	67	857	840	*e*	498	788	*e*	196	740	*e*	166	695	*e*	131	650	*e*	94	615	*e*
	Small " ...	589	887	*e*	409	780	*e*	186	740	*e*	107	710	*e*	75	670	*e*	60	635	*e*	47	600	*e*	36	563	*e*

e denotes that all the bullets are effective.

i denotes that all the bullets are ineffective.

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7. Again, for short ranges, the least angle of descent is given by the lowest bounding trajectory of the cone of dispersion, while for long ranges it is given by the upper one.

The following table gives the least angle of descent, the asterisk being placed over those belonging to the lower trajectory.

TABLE III.

Range in yards.		500		1000		1500		2000		2500		3000		3500		4000	
		°	′	°	′	°	′	°	′	°	′	°	′	°	′		
7-pr.	Large bullets	*6	50	5	10	3	43	5	26	9	24	14	45	20	45	—	
	Small "	*7	20	5	40	4	23	5	40	9	0	14	12	20	10	—	
2·5-inch	Large "	*5	50	*8	10	6	45	5	28	4	35	5	40	8	38	12	30
	Small "	*6	40	*9	0	—		—		—		7	0	8	29	11	20
9-pr.	Large "	*4	40	5	12	3	30	3	0	4	35	7	23	10	22	14	5
	Small "	*5	0	5	50	3	50	3	13	4	30	6	50	9	54	13	37
12-pr. steel shell		*6	50	*8	50	*11	10	*13	50	12	0	9	0	7	10	7	1
13-pr.	Steel shell	*5	0	*6	30	6	12	3	40	3	10	3	32	5	38	7	30
	Cast-iron shell	*4	30	*5	0	*5	30	4	8	3	20	3	50	5	47	*7	25
16-pr.	Large bullets	*5	0	6	0	4	0	3	40	3	20	5	54	7	50	11	28
	Small "	2	26	2	12	2	18	3	44	5	42	8	30	10	38	14	40

8. To calculate the foregoing tables, it was first necessary to obtain a table for calculating the times of flight, range attained, and the angles of descent of spherical projectiles, in order to obtain the trajectories of the bullets contained in the shrapnel shell. The trajectory of the shell itself was calculated with the aid of Professor Greenhill's "*Gunnery Table.*"

The times of flight and range attained of spherical projectiles have been tabulated by Mr. Bashforth from his experiments on spherical projectiles, and the angles of descent have been calculated by Mr. W. D. Niven, but in making use of these results, three different tables have to be used, which makes the work very laborious, even supposing them printed in the same book. Again, for ordinary use, they are far too copious, so that it was considered advisable to construct a new table, taking Professor Greenhill's "*Gunnery Table*" as the type.

9. In Mr. Bashforth's tables the lowest velocity is taken at 500 f.s., although in experimenting a minimum velocity of 850 f.s. only was reached. The tables were continued for the lower velocities by calculation, it being assumed that the pressure on the projectile, due

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to the atmosphere, varies as the cube of the velocity; or, if p is the pressure in lbs. on the circular inch, v the velocity, and g the acceleration of gravity,—

$$p = \frac{K}{g}\left(\frac{v}{1000}\right)^3$$

where K is a certain co-efficient, which was found to vary in the experiments, but which was considered constant for velocities below 850 f.s. for the purposes of calculation.

But as K varied for velocities above 850 f.s., it is only natural to suppose that it varied for lower velocities; in fact, Mr. Bashforth has calculated K for projectiles with ogival heads for velocities as low as 100 f.s., in which it varies very considerably—*see table* (*H*) Bashforth's "*Supplement to Motion of Projectiles*," or "*Final Report on Experiments with the Bashforth Chronograph, 1880.*"

10. In order to obtain K, or what amounts to the same thing, the pressure p for the lower velocities, recourse was had to a curve drawn so as to connect p and v. Such a curve has been plotted out with the velocity as the abscissa and the pressures as ordinates (*see curve* C *in* "*Calculation of Trajectories*," *Vol. XIII., R.A.I. Proceedings*).

The pressures p were calculated from the above formula, with the values of K given in Bashforth's "*Motion of Projectiles*," Table II., but of course this curve ended with a minimum velocity of 850 f.s.

It was then suggested that the curve should be produced downwards, it being known that it must pass through the origin of co-ordinates, since if $v = 0$, $p = 0$ necessarily. The pressure p being the difference of pressures on the front and rear of the projectile, it is therefore only called into existence when there is a velocity imparted to the projectile.

This was done, and the pressures were measured off for differences of velocity of 10 f.s. from 850 f.s. to 300 f.s. It was not thought necessary to go below 300 f.s., as it is considered that a field shrapnel bullet should have a greater velocity than 400 f.s.

The pressures were then corrected by making their second or third differences as nearly constant as possible according to the method indicated in Bashforth's "*Motion of Projectiles*," pp. 38 – 43.

11. These pressures have been compared, in Table IV., with those obtained by Robins, who experimented about the year 1746, and Hutton about 1800, on the resistance of the air to spherical projectiles, *vide* Boxer's "*Treatise on Artillery*," p. 102, with those of Mr. Bashforth, supposing K to be constant, and with the Russian experiments—Captain Ingall's "*Exterior Ballistics*," Table II.

The experiments by Robins and Hutton related to a ball 2 inches diameter, but as all modern tables relate to projectiles of unit diameter their results have to be divided by the square of the diameter.

The pressures in the Russian experiments were obtained by using the formula

$$p = \frac{\Delta v}{g \Delta T}$$

putting $\Delta v = 10$, and obtaining ΔT from the Table II., quoted above.

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TABLE IV.

v.	p in lbs. on the circular inch.				
	From curve C.	Bashforth's.	Russian.	Robins and Hutton's	
				Theory.	Experiment.
300	·254	·116	—	·288	·403
400	·439	·275	—	·511	·727
500	·704	·537	·520	·800	1·163
600	1·070	·929	·880	1·150	1·725
700	1·580	1·475	1·412	1·566	2·438
800	2·221	2·201	2·172	2·045	3·313
900	3·130	3·130	3·203	2·589	4·380
1000	4·383	4·383	4·707	3·197	5·658
1100	6·260	6·260	6·472	3·869	7·128
1200	8·234	8·234	8·876	4·603	8·819
1300	10·086	10·086	10·712	5·402	10·677
1400	12·041	12·041	—	6·266	12·680

12. Comparing Robins and Hutton's experimental results with the Russian and Bashforth's, it appears that their pressures are much too high for velocities below 1200 f.s. For velocities above 850 f.s., Mr. Bashforth's values were obtained with great care from experiment, and the Russian experiments agree very closely with them; so that for velocities above this value we shall take these as being correct. For velocities below 850 f.s., Mr. Bashforth's and the Russian results are much lower than those supplied by Robins' and Hutton's theory, while those obtained from the curve agree very fairly with the latter. Robins considered that up to a velocity of 1100 f.s., the resistance of the atmosphere to the projectile was proportional to the square of the velocity; and from experiments conducted at Meppen, Krupp comes to the conclusion that the pressure varies as the square of the velocity between 370 m.s. and 910 m.s., *i.e.*, between 1214 f.s. and 2986 f.s.

Mr. Bashforth has deduced a similar law from his own experiments.

We may therefore fairly consider the values given by the curve as approximately correct.

13. The whole of the pressures are not shown, but from them the differences Δ T, Δ S, and Δ D, tabulated in the spherical projectile table were calculated.

Thus $$\Delta T = \frac{\Delta v}{p g} \text{ where } \Delta v = 10$$

$$\Delta S = v \Delta T$$

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and $$\Delta D = \frac{180g}{\pi} \frac{\Delta T}{v}$$ where $\pi = 3{\cdot}1416$.

The method of obtaining these formulæ in a simple manner is shown in "*The Calculation of Trajectories*," *R.A.I. Proceedings, Vol. XIII.*

The differences for velocities above 850 f.s. have been re-calculated in order to make the whole of the table uniform. The differences were assumed by means of the Arithmometer in the R. A. Institution, and ranged in the columns T, S and D, in a similar manner to Professor Greenhill's "*Gunnery Table.*"

The Δ T and T columns are of little use for calculating the time in the case of shrapnel bullets, as the time of flight of the shell alone would generally be required, but the above table may be used for any spherical projectile, and then these columns would be of great use.

14. We shall now give an example of the method used in the calculation of Tables I. and II.

Colonel Hawkins has very kindly furnished me with most of the data concerning the shells of the different guns, and we shall give all that is necessary for the work below.

Starting with the guns. The rifling in the

7-pr. of 3 inches, 200 lbs., is a uniform twist of 1 turn in 20 calibres.
2·5-inch jointed gun, an increasing to uniform twist of 1 turn in 30 calibres.
9-pr., of 3 inches, an increasing to uniform twist of 1 turn in 30 calibres.
12-pr., 3 „ „ „ „ „ 28 „
13-pr., 3 „ „ „ „ „ 30 „
16-pr., 3·6 „ „ „ „ „ 30 „

The muzzle velocities are, in the

7-pr. 200 lbs.	968 f.s.
2·5-inch	1440 „
9-pr.	1398 „
12-pr.	1700 „
13-pr.	1595 „
16-pr.	1355 „

In finding the value of $\frac{d^2}{w}$ the amount of windage of the shell ought to be taken into account.

Thus the diameter of the bore of the 13-pr. is 3 inches, but the diameter of the shell is 2·97 inches, and its weight is 13 lbs.

$$\therefore \quad \frac{d^2}{w} = \frac{(2{\cdot}97)^2}{13} = {\cdot}6785.$$

In the 7-pr. $\frac{d^2}{w}$	= 1·1150
2·5-inch „	= ·8715
9-pr. „	= ·8860
12-pr. „	= ·7056
13-pr. „	= ·6785
16-pr. „	= ·7060

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15. For the example we will take both kinds of shell of the 13-pr. As the diameter and weight of each is equal, the $\frac{d^2}{w}$ is the same in both shells, and we shall only have to find one trajectory at each range for the shell itself. But the bullets in the steel shell receive an acceleration of 200 f.s., at the time of burst; so we have to find the trajectories for the bullets in each shell separately. We will suppose the range to be 2000 yards, and that the shell is burst 50 yards short.

We first find the velocity of the shell at the end of the range and at the point of burst.

Here $V = 1595$ f.s., the initial velocity, $\frac{d^2}{w} = \cdot 6785$.

For the point of burst $s = 1950$ yards $= 5850$ feet.

$$S^{v_1}_{V} = \frac{d^2}{w}\, s = \cdot 6785 \times 5850 = 3969 \cdot 225$$

Using Professor Greenhill's *Gunnery Table*

$$S_{1595} = 42506 \cdot 090$$
$$S^{v_1}_{V} = \quad 3969 \cdot 225$$
$$S_{v_1} = 38536 \cdot 865$$
$$\therefore \quad v_1 = 983 \text{ f.s.}$$

For the end of the range the shell has to travel 50 yards further, so that $s = 50$ yards $= 150$ feet.

$$S^{v_2}_{v_1} = \frac{d^2}{w}\, s = \cdot 6785 \times 150 = 101 \cdot 775$$
$$S_{v_1} = 38536 \cdot 865$$
$$S^{v_2}_{v_1} = 101 \cdot 775$$
$$S_{v_2} = 38435 \cdot 09$$
$$\therefore \quad v = 975 \text{ f.s.}$$

We now find the times of flight. For the point of burst:—

$$T_V = 157 \cdot 0336$$
$$T_{v_1} = 153 \cdot 7411$$
$$T^{v_1}_{V} = 3 \cdot 2925 = t\,\frac{d^2}{w}.$$

$$\therefore \text{ Time of flight } t_1 = \frac{3 \cdot 2925}{\cdot 6785} = 4 \cdot 8526 \text{ secs.}$$

For the end of the range:—

$$T_V = 157 \cdot 0336$$
$$T_{v_2} = 153 \cdot 6274$$
$$T^{v_2}_{V} = \quad 3 \cdot 4062$$
$$\therefore \quad t_2 = \frac{3 \cdot 4062}{\cdot 6785} = 5 \cdot 0202 \text{ secs.}$$

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To find the height of burst above the ground we use the formula,

$$h = \tfrac{1}{2} g t_1 (t_2 - t_1).$$

This is not strictly correct as it does not take in the resistance of the atmosphere, but it will be sufficiently near for our purpose.

$$\begin{aligned} t_2 - t_1 &= \cdot 1676 \\ \log \tfrac{1}{2}g &= 1 \cdot 2067018 \\ \log t_1 &= \cdot 6859759 \\ \log (t_2 - t_1) &= \bar{1} \cdot 2242740 \\ \log h &= 1 \cdot 1169517 \\ h &= 13 \cdot 09 \text{ feet.} \end{aligned}$$

16. It was intended at first to make Table I. include bursts of 200 yards and 150 yards short, so the same calculations were made for bursts of 100 yards, 150 yards and 200 yards short at the same range, and the heights of these found; but owing to the length of time taken in making the calculations these were abandoned.

These heights are, in the present example, for

200	yards	short	...	...	...	43·1	feet.
150	,,	,,	...	...	...	34·3	,,
100	,,	,,	...	...	...	24·5	,,
50	,,	,,	...	...	...	13·1	,,

This part of the trajectory was then plotted out with these heights as ordinates, and the distances of point of burst from the end of the range as abscissæ.

The angles of descent at each point of burst were then carefully measured. These were found to be for the shell bursting,

200	yards	short	...	...	...	3°	11′.
150	,,	,,	...	...	...	3°	34′.
100	,,	,,	...	...	...	4°	3′.
50	,,	,,	...	...	...	4°	37′.

17. We now have to find the linear velocity of rotation of the bullets in the shell.

If n = number of calibres to 1 turn in the rifling,
V = muzzle velocity,
d = diameter of bore of gun,
r = distance of the centre of bullet from centre of rotation.

Then the linear velocity of rotation

$$R = \frac{24 \pi V r}{n d}$$

or if θ = angle of rifling,

$$R = 2V \frac{r}{d} \tan \theta.$$

Throughout the range we shall consider that no diminution takes place in the velocity of rotation, and that the axis of the projectile

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moves tangential to the trajectory. We have no means of getting at the remaining velocity of rotation, but experience shows that it diminishes very slowly. Both the French and Italian writers, in the papers already quoted, consider the velocity of rotation to remain the same throughout.

18. If 2ψ is the angle of the cone of dispersion,

$$\tan \psi = \frac{R}{v}$$

where v is the remaining velocity at the point of burst; in the case of the 13-pr. steel shell 200 f.s. has to be added, and in the 12-pr. and 2·5-inch, 200 f.s. and 100 f.s. have to be deducted respectively.

In reality, the bullets do not move along a cone, but on the surface of a hyperboloid distorted by gravity. The asymptotic cone of this hyperboloid approaches it so rapidly that for all ordinary calculations it is only necessary to consider the former. The mathematical model of the hyperboloid formed of two circular discs some distance apart with stretched silk cord joining the discs obliquely at intervals around their circumference, shows the action of shrapnel bursting admirably. The smallest diameter of the hyperboloid may be considered a ring of bullets rotating in the shell and the silk cords their trajectories after burst.

19. The following gives the angle of cone for each range, supposing the shell burst 50 yards short in each instance :—

	Angles of cone.							
Range in yards	500	1000	1500	2000	2500	3000	3500	4000
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
7-pr. ... Large bullets ...	10 38	11 46	13 0	14 22	15 52	17 32	19 22	21 22
7-pr. ... Small " ...	11 34	12 48	14 8	15 38	17 14	19 2	21 2	23 10
2·5-inch Large " ...	9 56	11 46	13 8	14 30	15 52	17 22	18 58	20 48
2·5-inch Small " ...	11 24	13 28	15 0	16 34	18 8	19 50	21 38	23 44
9-pr. ... Large " ...	7 32	8 44	9 36	10 30	11 24	12 20	13 20	14 26
9-pr. ... Small " ...	8 12	9 28	10 26	11 24	12 22	13 24	14 30	15 40
12-pr. steel shell	11 50	14 8	16 38	18 46	20 38	22 34	24 34	26 42
13-pr. ... Steel shell	8 20	9 26	10 30	11 14	11 56	12 36	13 14	13 54
13-pr. ... Cast-iron shell ...	7 58	9 6	10 20	11 16	12 8	12 58	13 48	14 38
16-pr. ... Large bullets ...	7 48	8 48	9 34	10 18	11 0	11 44	12 30	13 20
16-pr. ... Small " ...	3 48	4 18	4 40	5 0	5 22	5 44	6 6	6 30

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By calculation these angles increase from 6′ to 10′ for every extra 50 yards short the burst takes place.

20. We now proceed to find the trajectories of the bullets for our example. Taking the steel shell.

The angle of descent of the shell is 4° 37′, and half the angle of the cone of dispersion is 5° 37′. Therefore the bullet in the upper trajectory of the cone has

$$5° 37' - 4° 37' = 1° \text{ of elevation.}$$

The lower trajectory of the cone has an angle of descent of

$$5° 37' + 4° 37' = 10° 14'.$$

Taking the upper trajectory and working by Niven's method, using the Spherical Projectile Table.

In this case there will be an ascending branch.

Here $\alpha = 1°, \ \beta = 0, \ D = 1°.$

The bullets in the shell are ·51-in. diameter, so that

$$\frac{d^2}{w} = 8{\cdot}8434$$

and

$$\log \frac{d^2}{w} = \ {\cdot}9466193.$$

200 f.s. has to be added on for the action of the bursting charge;

$$\therefore \ V = 983 + 200 = 1183 \text{ f.s.}$$

$$\bar{\phi}_1 = \frac{\alpha}{2} = 30'$$

$$D_v = D_V - \frac{d^2}{w} D,$$

$$= 106{\cdot}1029 - 8{\cdot}8434,$$

$$= \ 97{\cdot}2595,$$

or $v = 727$ f.s.

Computing the value of $\bar{\phi}$,

$$\bar{\phi} = \bar{\phi}_1 + \frac{p - q}{p + q} \frac{D}{3} = \bar{\phi}_1 + \frac{V - v}{V + v} \frac{D}{3} \text{ nearly}$$

$$= 30' + \frac{1183 - 727}{1183 + 727} \frac{60}{3}$$

$$= 34'.$$

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$$X = \frac{w}{d^2} \cos \bar{\phi} \, (S_V - S_v)$$

$$S_{1183} - S_{727} = 13476{\cdot}18 - 9711{\cdot}52$$
$$= 3764{\cdot}66.$$

$$\therefore \quad \log X = \log 3764{\cdot}66 + L \cos \bar{\phi} - 10 - \log \frac{d^2}{w}$$
$$= 3{\cdot}5757257 + 9{\cdot}9999788 - 10 - {\cdot}9466193$$
$$= 2{\cdot}6290852$$

and $X = 425{\cdot}68$ feet.

$$Y = \frac{w}{d^2} \sin \bar{\phi} \, (S_V - S_v)$$

$$\therefore \quad \log Y = 3{\cdot}5757257 + 7{\cdot}9951980 - 10 - {\cdot}9466193$$
$$= {\cdot}6243044$$

and $Y = 4{\cdot}21$ feet.

To this height has to be added the height of burst above the ground, so that the highest point reached by any bullet is

$$4{\cdot}21 + 13{\cdot}1 = 17{\cdot}31 \text{ feet.}$$

21. For the descending branch,

$$a = 0, \quad \beta = 3^\circ \ 40', \quad D = 3^\circ \ 40', \quad V = 727 \text{ f.s.}$$

$$\bar{\phi}_1 = \frac{\beta}{2} = 1^\circ \ 50'.$$

$$D_v = D_{727} - \frac{d^2}{w} D$$
$$= 97{\cdot}2595 - 32{\cdot}4258 = 64{\cdot}8337$$

or $v = 443$ f.s.

$$\bar{\phi} = \bar{\phi}_1 - \frac{p - q}{p + q} \frac{D}{3} = \bar{\phi}_1 - \frac{V - v}{V + v} \frac{D}{3} \text{ nearly.}$$

$$= 1^\circ \ 50' - \frac{727 - 443}{727 + 443} \frac{220}{3}$$

$$= 1^\circ \ 32'.$$

$$X' = \frac{w}{d^2} \cos \bar{\phi} \, (S_{727} - S_{443})$$

$$S_{727} - S_{443} = 9711{\cdot}52 - 4428{\cdot}18$$
$$= 5283{\cdot}34;$$

$$\therefore \quad \log X' = 3{\cdot}7229086 + 9{\cdot}9998445 - 10 - {\cdot}9466193$$
$$= 2{\cdot}8261338,$$

and $X' = 670{\cdot}1$ feet.

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$$Y' = \frac{w}{d^2} \sin \bar{\phi} \, (S_{727} - S_{443})$$

$$\log Y' = 3{\cdot}7729086 + 8{\cdot}4274621 - 10 - {\cdot}9466193$$
$$= 1{\cdot}2537514,$$
$$\therefore \quad Y' = 17{\cdot}93 \text{ feet.}$$

This bullet has therefore dropped $17{\cdot}93 - 17{\cdot}31 = {\cdot}62$ feet too much, so by approximation

$$X'' = {\cdot}62 \cot 3^\circ 40' = {\cdot}62 \times 15{\cdot}6$$
$$= 9{\cdot}67 \text{ feet.}$$

22. Now taking the lower trajectory of the cone. Here we have only the descending branch, and the height the bullets have to fall is 13·1 feet.

We shall work this case carefully and also approximately, and compare the results.

Here $\alpha = 10^\circ\ 14'$, $\beta = 10^\circ\ 22'$, $D = 8'$, $V = 1183$ f.s.

$$\bar{\phi}_1 = \frac{\alpha + \beta}{2} = 10^\circ\ 18',$$

$$p = V \cos \alpha = 1164,$$

$$p \sec \bar{\phi}_1 = 1183{\cdot}2 = 1183 \text{ nearly.}$$

$$D_{q \sec \phi_1} = D_{p \sec \phi_1} - \frac{d^2}{w} D \sec \bar{\phi}_1$$
$$= 106{\cdot}1029 - 1{\cdot}1984$$
$$= 104{\cdot}9045$$

$$\therefore \quad q \sec \bar{\phi}_1 = 1039\text{;} \quad \text{the final velocity, very nearly.}$$
$$\text{and} \quad q = 1022.$$

For correcting the value of $\bar{\phi}_1$ we have

$$\bar{\phi} = \bar{\phi}_1 - \frac{D}{3} \frac{p - q}{p + q}$$
$$= 10^\circ\ 18' - \frac{8}{3} \frac{1164 - 1022}{1164 + 1022}$$
$$= 10^\circ\ 17'{\cdot}83$$

$$X_1 = \frac{w}{d^2} \cos \bar{\phi} \, (S_{p \sec \bar{\phi}} - S_{q \sec \phi})$$

$$S_{p \sec \bar{\phi}} - S_{q \sec \phi} = 13476{\cdot}18 - 12690{\cdot}70$$
$$= 785{\cdot}48.$$

$$\log X_1 = \log 785{\cdot}48 + L \cos \bar{\phi} - 10 - \log \frac{d^2}{w}$$
$$= 2{\cdot}8951351 + 9{\cdot}9929863 - 10 - {\cdot}9466193$$
$$= 1{\cdot}9415021.$$

$$\therefore \quad X_1 = 87{\cdot}4 \text{ feet.}$$

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$$Y_1 = \frac{w}{d^2} \sin \bar{\phi} \, (S_p \sec \bar{\phi} - S_q \sec \bar{\phi})$$

$$\log Y_1 = \log 785{\cdot}48 + L \sin \bar{\phi} - 10 - \log \frac{d^2}{w}$$

$$= 2{\cdot}8951351 + 9{\cdot}2522546 - 10 - {\cdot}9466193$$

$$= 1{\cdot}2007704$$

$$\therefore \quad Y_1 = 15{\cdot}87 \text{ feet.}$$

But this bullet has only to fall 13·1 feet, so it has fallen 2·77 feet too much.

Therefore correcting the value of X_1, approximately we have

$$X_1' = 87{\cdot}4 - 2{\cdot}77 \cot \bar{\phi}$$

$$= 87{\cdot}4 - 15{\cdot}1$$

$$= 72{\cdot}3 \text{ feet.}$$

Comparing this with a result found approximately

$$X_1 = 13{\cdot}1 \cot \alpha$$

$$= 72{\cdot}56 \text{ feet.}$$

These two results are so nearly alike, that for small falls the latter method has been used in all cases.

23. The major axis of the ellipse of dispersion, in the case of the steel shell, is therefore

$$X + X' - X'' - X_1'$$

$$= 425{\cdot}68 + 670{\cdot}1 - 9{\cdot}67 - 72{\cdot}3$$

$$= 1013{\cdot}81$$

$$= 1014 \text{ feet nearly.}$$

24. We will now work out a similar result for the cast-iron shell.

The angle of descent is 4° 37′, as in the last case, and half the angle of the cone of dispersion is 5° 38′. Therefore in the upper trajectory of the cone a bullet has

$$5° \ 38' - 4° \ 37' - 1° \ 1'$$

of elevation; and the lower trajectory has an angle of descent of

$$5° \ 38' + 4° \ 37' = 10° \ 15'.$$

Taking the upper trajectory. In the ascending branch we have

$$\alpha = 1° \ 1', \quad \beta = 0, \quad D = 61', \quad V = 983 \text{ f.s.},$$

$$\frac{d^2}{w} = 8{\cdot}8434, \quad \text{as before.}$$

$$\bar{\phi}_1 = \frac{\alpha}{2} = 30'{\cdot}5$$

$$D_v = D_V - \frac{d^2}{w} D,$$

$$= 104{\cdot}1905 - 8{\cdot}9907$$

$$= 95{\cdot}1998$$

$$\text{or} \quad v = 688 \text{ f.s.}$$

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Correcting the value of $\bar{\phi}_1$

$$\bar{\phi} = \bar{\phi}_1 + \frac{D}{3}\frac{V-v}{V+v} = 30'{\cdot}5 + \frac{61}{3}\frac{295}{1671}$$
$$= 34'{\cdot}1.$$

$$X = \frac{w}{d^2}\cos\bar{\phi}\,(S_V - S_v)$$
$$S_V - S_v = 12299{\cdot}67 - 9177{\cdot}44$$
$$= 3122{\cdot}23.$$
$$\log X = 3{\cdot}4944649 + 9{\cdot}9999789 - 10 - {\cdot}9466193$$
$$= 2{\cdot}5478245$$
and $X = 353$ feet.

$$Y = \frac{w}{d^2}\sin\bar{\phi}\,(S_V - S_v)$$
$$\log Y = 3{\cdot}4944649 + 7{\cdot}9964568 - 10 - {\cdot}9466193$$
$$= {\cdot}5443024$$
and $Y = 3{\cdot}5$ feet.

Adding the height of burst, the highest point reached by any bullet is

$$3{\cdot}5 + 13{\cdot}1 = 16{\cdot}6 \text{ feet.}$$

25. For the descending branch

$$\alpha = 0, \quad \beta = 3^\circ\ 40', \quad D = 3^\circ\ 40', \quad V = 688 \text{ f.s.}$$
$$\bar{\phi}_1 = \frac{\beta}{2} = 1^\circ\ 50',$$
$$D_v = D_{688} - \frac{d^2}{w}D,$$
$$= 95{\cdot}1998 - 32{\cdot}4258 = 62{\cdot}7740,$$
or $v = 435$ f.s.
$$\bar{\phi} = \bar{\phi}_1 - \frac{D}{3}\frac{V-v}{V+v} = 1^\circ\ 50' - \frac{220}{3}\frac{253}{1123}$$
$$= 1^\circ\ 34'.$$
$$S_V - S_v = 9177{\cdot}44 - 4219{\cdot}85$$
$$= 4957{\cdot}59$$
$$\log X' = 3{\cdot}6952705 + 9{\cdot}9998376 - 10 - {\cdot}9466193$$
$$= 2{\cdot}7484988,$$
and $X' = 560{\cdot}4$ feet.
$$\log Y' = 3{\cdot}6952705 + 8{\cdot}4367999 - 10 - {\cdot}9466193$$
$$= 1{\cdot}1854511,$$
and $Y' = 15{\cdot}33$ feet.

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This bullet has not therefore dropped far enough by 16·6 − 15·33 = 1·27 feet. So approximating

$$X'' = 1{\cdot}27 \cot 3^\circ\ 40' = 1{\cdot}27 \times 15{\cdot}6$$
$$= 19{\cdot}8 \text{ feet.}$$

Taking the lower trajectory, approximately we have

$$X_1 = 13{\cdot}1 \cot 10^\circ\ 15'$$
$$= 13{\cdot}1 \times 5{\cdot}53$$
$$= 72{\cdot}4 \text{ feet}$$

Therefore the major axis of the ellipse of dispersion is

$$X + X' + X'' - X_1$$
$$= 353 + 560{\cdot}4 + 19{\cdot}8 - 72{\cdot}4,$$
$$= 860{\cdot}8 = 861 \text{ feet, nearly.}$$

[Spherical Projectile Table.—

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SPHERICAL PROJECTILE TABLE.

v	ΔT	T	ΔS	S	ΔD	D
f.s.						
300	1·2232	0·0000	366·91	0·00	7·5191	0·0000
310	1·1505	1·2232	356·67	366·91	6·8454	7·5191
320	1·0824	2·3737	346·37	723·58	6·2387	14·3645
330	1·0217	3·4561	337·22	1069·95	5·7113	20·6032
340	0·9647	4·4778	328·01	1407·17	5·2335	26·3145
350	0·9137	5·4425	319·78	1735·18	4·8148	31·5480
360	0·8653	6·3562	311·51	2054·96	4·4333	36·3628
370	0·8218	7·2215	304·07	2366·47	4·0967	40·7961
380	0·7805	8·0433	296·60	2670·54	3·7884	44·8928
390	0·7432	8·8238	289·84	2967·14	3·5147	48·6812
400	0·7076	9·5670	283·05	3256·98	3·2629	52·1959
410	0·6753	10·2746	276·88	3540·03	3·0380	55·4588
420	0·6445	10·9499	270·69	3816·91	2·8303	58·4968
430	0·6151	11·5944	264·51	4087·60	2·6385	61·3271
440	0·5763	12·2095	253·59	4352·11	2·4159	63·9656
450	0·5508	12·7858	247·86	4605·70	2·2575	66·3815
460	0·5265	13·3366	242·20	4853·56	2·1111	68·6390
470	0·5035	13·8631	236·64	5095·76	1·9758	70·7501
480	0·4816	14·3666	231·18	5332·40	1·8506	72·7259
490	0·4609	14·8482	225·84	5563·58	1·7349	74·5765
500	0·4413	15·3091	220·63	5789·42	1·6277	76·3114
510	0·4227	15·7504	215·55	6010·05	1·5285	77·9391
520	0·4050	16·1731	210·61	6225·60	1·4366	79·4676
530	0·3883	16·5781	205·80	6436·21	1·3513	80·9042
540	0·3725	16·9664	201·14	6642·01	1·2722	82·2555
550	0·3575	17·3389	196·61	6843·15	1·1988	83·5277
560	0·3429	17·6964	192·01	7039·76	1·1293	84·7265
570	0·3291	18·0393	187·57	7231·77	1·0648	85·8558
580	0·3157	18·3684	183·11	7419·34	1·0039	86·9206
590	0·3028	18·6841	178·64	7602·45	0·9465	87·9245
600	0·2903	18·9869	174·19	7781·09	0·8925	88·8710
610	0·2786	19·2772	169·95	7955·28	0·8424	89·7635
620	0·2673	19·5558	165·75	8125·23	0·7953	90·6059
630	0·2567	19·8231	161·74	8290·98	0·7516	91·4012
640	0·2467	20·0798	157·92	8452·72	0·7111	92·1528
650	0·2371	20·3265	154·14	8610·64	0·6739	92·8639
660	0·2281	20·5636	150·53	8764·78	0·6374	93·5368
670	0·2195	20·7917	147·09	8915·31	0·6044	94·1742
680	0·2115	21·0112	143·80	9062·40	0·5736	94·7786
690	0·2038	21·2227	140·65	9206·20	0·5449	95·3522
700	0·1966	21·4265	137·63	9346·85	0·5180	95·8971
710	0·1898	21·6231	134·73	9484·48	0·4930	96·4151
720	0·1832	21·8129	131·88	9619·21	0·4692	96·9081
730	0·1770	21·9961	129·22	9751·09	0·4472	97·3773
740	0·1711	22·1731	126·59	9880·31	0·4264	97·8245
750	0·1653	22·3442	123·99	10006·90	0·4066	98·2509
760	0·1600	22·5095	121·57	10130·89	0·3882	98·6575
770	0·1547	22·6695	119·13	10252·46	0·3706	99·0457
780	0·1496	22·8242	116·72	10371·58	0·3539	99·4163
790	0·1447	22·9738	114·30	10488·30	0·3378	99·7702
800	0·1399	23·1185	111·89	10602·60	0·3225	100·1080
810	0·1352	23·2584	109·50	10714·49	0·3078	100·4305
820	0·1306	23·3936	107·07	10823·99	0·2937	100·7383
830	0·1261	23·5242	104·68	10931·06	0·2803	101·0320
840	0·1218	23·6503	102·33	11035·74	0·2675	101·3123
850	0·1177	23·7721	100·01	11138·07	0·2553	101·5798
860	0·1137	23·8898	97·76	11238·08	0·2438	101·8351

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SPHERICAL PROJECTILE TABLE—continued.

v	ΔT	T	ΔS	S	ΔD	D
f.s.						
870	0·1098	24·0035	95·53	11335·84	0·2328	102·0789
880	0·1062	24·1133	93·44	11431·37	0·2225	102·3117
890	0·1026	24·2195	91·35	11524·81	0·2127	102·5342
900	0·0993	24·3221	89·33	11616·16	0·2034	102·7469
910	0·0959	24·4214	87·32	11705·49	0·1945	102·9503
920	0·0928	24·5173	85·37	11792·81	0·1860	103·1448
930	0·0898	24·6101	83·48	11878·18	0·1780	103·3308
940	0·0869	24·6999	81·65	11961·66	0·1704	103·5088
950	0·0840	24·7868	79·83	12043·31	0·1631	103·6792
960	0·0813	24·8708	78·01	12123·14	0·1561	103·8423
970	0·0785	24·9521	76·19	12201·15	0·1493	103·9984
980	0·0759	25·0306	74·43	12277·34	0·1429	104·1477
990	0·0734	25·1065	72·67	12351·77	0·1368	104·2906
1000	0·0709	25·1799	70·87	12424·44	0·1307	104·4274
1010	0·0684	25·2508	69·08	12495·31	0·1249	104·5581
1020	0·0660	25·3192	67·31	12564·39	0·1193	104·6830
1030	0·0636	25·3852	65·55	12631·70	0·1140	104·8023
1040	0·0614	25·4488	63·81	12697·25	0·1088	104·9163
1050	0·0591	25·5102	62·08	12761·06	0·1039	105·0251
1060	0·0570	25·5693	60·42	12823·14	0·0992	105·1290
1070	0·0550	25·6263	58·82	12883·56	0·0948	105·2282
1080	0·0531	25·6813	57·31	12942·38	0·0906	105·3230
1090	0·0513	25·7344	55·89	12999·69	0·0868	105·4136
1100	0·0496	25·7857	54·59	13055·58	0·0832	105·5004
1110	0·0481	25·8353	53·36	13110·17	0·0799	105·5836
1120	0·0466	25·8834	52·21	13163·53	0·0768	105·6635
1130	0·0453	25·9300	51·15	13215·74	0·0739	105·7403
1140	0·0440	25·9753	50·16	13266·89	0·0712	105·8143
1150	0·0428	26·0193	49·23	13317·05	0·0687	105·8854
1160	0·0417	26·0621	48·35	13366·28	0·0663	105·9541
1170	0·0406	26·1038	47·53	13414·63	0·0640	106·0204
1180	0·0396	26·1444	46·73	13462·16	0·0619	106·0844
1190	0·0386	26·1840	45·97	13508·89	0·0599	106·1463
1200	0·0377	26·2226	45·27	13554·86	0·0580	106·2062
1210	0·0369	26·2603	44·61	13600·13	0·0562	106·2642
1220	0·0361	26·2972	44·00	13644·74	0·0545	106·3204
1230	0·0353	26·3333	43·43	13688·74	0·0529	106·3749
1240	0·0346	26·3686	42·87	13732·17	0·0514	106·4278
1250	0·0339	26·4032	42·36	13775·04	0·0500	106·4792
1260	0·0332	26·4371	41·85	13817·40	0·0486	106·5292
1270	0·0326	26·4703	41·39	13859·25	0·0473	106·5778
1280	0·0320	26·5029	40·94	13900·64	0·0461	106·6251
1290	0·0314	26·5349	40·49	13941·58	0·0449	106·6712
1300	0·0308	26·5663	40·04	13982·07	0·0437	106·7161
1310	0·0302	26·5971	39·59	14022·11	0·0425	106·7598
1320	0·0297	26·6273	39·18	14061·70	0·0415	106·8023
1330	0·0291	26·6570	38·75	14100·88	0·0404	106·8438
1340	0·0286	26·6861	38·33	14139·63	0·0394	106·8842
1350	0·0281	26·7147	37·92	14177·96	0·0384	106·9236
1360	0·0276	26·7428	37·52	14215·88	0·0374	106·9620
1370	0·0271	26·7704	37·15	14253·40	0·0365	106·9994
1380	0·0267	26·7975	36·80	14290·55	0·0356	107·0359
1390	0·0262	26·8242	36·45	14327·35	0·0348	107·0715
1400	0·0258	26·8504	36·11	14363 80	0·0340	107·1063
1410	0·0254	26·8762	35·77	14399·91	0·0332	107·1403
1420	0·0250	26·9016	35·48	14435·68	0·0324	107·1735
1430	0·0246	26·9266	35·16	14471·16	0·0317	107·2059

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SPHERICAL PROJECTILE TABLE—continued.

v	ΔT	T	ΔS	S	ΔD	D
f.s.						
1440	0·0242	26·9512	34·85	14506·32	0·0310	107·2376
1450	0·0238	26·9754	34·54	14541·17	0·0303	107·2686
1460	0·0235	26·9992	34·24	14575·71	0·0296	107·2989
1470	0·0231	27·0227	33·98	14609·95	0·0290	107·3285
1480	0·0228	27·0458	33·69	14643·93	0·0284	107·3575
1490	0·0224	27·0686	33·41	14677·62	0·0278	107·3859
1500	0·0221	27·0910	33·14	14711·03	0·0272	107·4137
1510	0·0218	27·1131	32·85	14744·17	0·0266	107·4409
1520	0·0214	27·1349	32·59	14777·02	0·0260	107·4675
1530	0·0211	27·1563	32·34	14809·61	0·0255	107·4935
1540	0·0208	27·1774	32·06	14841·95	0·0249	107·5190
1550	0·0205	27·1982	31·82	14874·01	0·0244	107·5439
1560	0·0202	27·2187	31·58	14905·83	0·0239	107·5683
1570	0·0200	27·2389	31·33	14937·41	0·0234	107·5922
1580	0·0197	27·2589	31·10	14968·74	0·0230	107·6156
1590	0·0194	27·2786	30·86	14999·84	0·0225	107·6386
1600	0·0191	27·2980	30·64	15030·70	0·0221	107·6611
1610	0·0189	27·3171	30·42	15061·34	0·0216	107·6832
1620	0·0186	27·3360	30·19	15091·76	0·0212	107·7048
1630	0·0184	27·3546	29·99	15121·95	0·0208	107·7260
1640	0·0182	27·3730	29·79	15151·94	0·0204	107·7468
1650	0·0179	27·3912	29·60	15181·73	0·0201	107·7672
1660	0·0177	27·4091	29·38	15211·33	0·0197	107·7873
1670	0·0175	27·4268	29·20	15240·71	0·0193	107·8070
1680	0·0173	27·4443	29·02	15269·91	0·0190	107·8263
1690	0·0171	27·4616	28·84	15298·93	0·0186	107·8453
1700	0·0168	27·4787	28·64	15327·77	0·0183	107·8639
1710	0·0167	27·4955	28·47	15356·41	0·0180	107·8822
1720	0·0165	27·5122	28·31	15384·88	0·0178	107·9002
1730	0·0163	27·5287	28·13	15413·19	0·0173	107·9178
1740	0·0161	27·5450	27·97	15441·32	0·0170	107·9351
1750	0·0159	27·5611	27·81	15469·29	0·0168	107·9521
1760	0·0157	27·5770	27·64	15497·10	0·0165	107·9689
1770	0·0155	27·5927	27·49	15524·74	0·0162	107·9854
1780	0·0154	27·6082	27·33	15552·23	0·0159	108·0016
1790	0·0152	27·6236	27·16	15579·56	0·0156	108·0175
1800	0·0150	27·6388	27·03	15606·72	0·0154	108·0331
1810	0·0148	27·6538	26·87	15633·75	0·0151	108·0485
1820	0·0147	27·6686	26·72	15660·62	0·0149	108·0636
1830	0·0145	27·6833	26·54	15687·34	0·0146	108·0785
1840	0·0143	27·6978	26·40	15713·88	0·0144	108·0931
1850	0·0142	27·7121	26·25	15740·28	0·0141	108·1075
1860	0·0140	27·7263	26·09	15766·53	0·0139	108·1216
1870	0·0139	27·7403	25·93	15792·62	0·0137	108·1355
1880	0·0137	27·7542	25·79	15818·55	0·0135	108·1492
1890	0·0136	27·7679	25·64	15844·34	0·0132	108·1627
1900	0·0134	27·7815	25·48	15869·98	0·0130	108·1759

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A NARRATIVE

OF

SIX WEEKS' SIEGE OPERATIONS.

BY

LIEUTENANT G. R. LAMB, R.A.

The second detachment for siege operations last summer consisted of two service batteries of Garrison Artillery, "4/1 Eastern," from Portsmouth, and "2/1 London," from Shoeburyness, commanded by Lieut.-Col. J. H. Blackley, R.A. The former under the command of Major Innes, R.A., mustered 1 captain, and 1 subaltern (attached), and about 90 N.C.O.'s and men; the latter under Captain Brady, R.A., consisted of 2 subalterns (1 attached) and, roughly, 75 duty men.

On arrival at Chatham on the 29th May, they found quarters at the Chatham Barracks.

The first day's work (1st June) was the disembarkation of the siege train from a barge in the gunwharf, and its transport by steam sappers to the gun park, under armed escorts.

During the succeeding operations the guns actually used were the 8-inch and 6·6-inch R.M.L. howitzers, and 40-pr. and 25-pr. R.M.L. guns on overbank carriages, one of each nature.

From the 2nd to the 5th June, the batteries were exercised in arming the siege batteries by day, and in all the drills and shifts, using the numerous methods of laying necessary by day and night. This was varied by instruction from an R. E. Instructor, in laying and removing platforms, tracing and digging gun pits and epaulments, and making fascines and gabions from brushwood. To obtain the brushwood the batteries had a most enjoyable journey to the Chattenden woods. They crossed the Medway in boats at Upnor, and marched to the R.E. Depôt for working tools and camp-cooking utensils. Thence a run of some 2½ miles over dangerous—to the uninitiated—curves and gradients in trucks drawn by an R. E. engine, followed by a march through the woods, brought the somewhat straggling detachments to a clearing, the scene of the work. The clear instructions given by the R. E. Qr.-Mr.-Sergeant, and the novelty of the task made the squads work with a keenness almost unknown in the operations of digging trenches and making field kitchens, which they went through during the course.

From the 8th to the 12th June all the above operations were carried out both by day and night, and practice in drills for an hour or two at

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a time under the strict conditions of active service. While arming the siege batteries by night, the electric light from the St. Mary's Barracks was thrown upon the working ground, forcing the squads to keep under cover of the trenches and approaches.

Draught by steam sappers, by teams furnished by D/3 R.A., and by manual labour, was employed alternately in the journeys by road from the Gun Park to the Batteries; while on other occasions the guns and stores were carried down on trench trolleys along the trench railway. It was assumed that the fire of the besieged had taken effect upon the batteries by damaging a gun and gun carriage; besides which the ammunition was considered to have been expended. The replenishment of the matériel meant some hours of traversing the railway line between 9 p.m. and midnight on the 11th.

The morning of the 15th June saw a new departure—the armament of the Field Redoubt on Tower Hill at Upnor. An "advance party," including the officer's servants and cooks carrying the meat rations, proceeded at 9 a.m. *viâ* the ferry, under an officer, to find the ranges of suitable aiming points, and to prepare the men's dinners. The remainder of the batteries paraded at the Gun Park, as the "advance," "main," and "rear guards" of the column of route. The men were in canvas "under arms," with rolled cloaks, water bottles filled, and havresacks containing canteen with the bread ration.

The four pieces and one general service wagon with stores were drawn by teams from D/3, R.A., under an officer.

The line of route was *viâ* the Military Road, New Road, Rochester Bridge, and Strood, a distance of some seven miles, which was accomplished within two hours. Upon reaching the Redoubt, the 6·6-inch howitzer and 40-pr. were mounted in the outer works, and the 6·3-inch howitzer and 25-pr. in the inner work or keep, and ready for action in three-quarters-of-an-hour. The road up the hill to the Redoubt was steep and narrow; the teams had to be reduced from four to three abreast, giving them a very stiff pull. Drill was carried out both before and after dinner, when the siege train was drawn down the hill and parked in the R. E. Depôt close to the river. The batteries then returned to barracks by the ferry at 4.30 p.m.

The batteries had considerable experience in the last few days at Chatham of work at night, which, however, was amply relieved by free time in the day.

Steam sappers were in requisition for the nights of the 16th and 17th, on the former to drag the siege train up to Tower Hill from its shelter of the previous day, and on the latter for the final disarmament, and homeward march to the Gun Park. It is needless to describe the proceedings here in full; for they were very similar in incidents to the other journeys. The whole course was finished with no greater misadventure than the overturning of a small cart in the streets of Strood by the leading gun team on the 15th, and it was with a feeling of relief the last piece was consigned on the 18th to the barge in the gunwharf to await the arrival of fresh workers of the 3rd detachment.

The fine weather, which had favoured almost continuously the first

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part of the course, seemed to have gone, as the detachment detrained alongside the tents of the Holmstone Camp at Lydd on the afternoon of the 19th June. Drizzling rain and flapping tents made a dreary scene; but an hour spent in unloading the baggage wagons and securing the tent-ropes, followed by "dinner up," made things look more cheerful.

The camp is pitched on very dry ground of sand and shingle covered with a little grass; but it was very dusty in a high wind, and the fixing of tent pegs was no easy matter. The permanent buildings consisted of good recreation and reading rooms for the men, the canteen, hospital—a tin house—and the workshops and store-rooms of the R.E., O.S.D., and C.T.C. The officers' mess tent, then in use, is now superseded by a small house.

During the stay of three weeks, the Infantry rifle ranges were much used in the intervals of the gun practice; but the fresh wind, which blew almost daily, was not conducive to good scoring.

The first two days (21st and 22nd) were occupied in carbine practice and fatigues, the 4-gun battery and 2-gun screened battery—a target—requiring considerable repairs. The former is made of shingle with a little clay in parts, revetted with sand bags (shingle) and iron-band gabions. The instability of the shingle made the repairs to the revetments much more tedious.

The ranges stretch roughly south from the Holmstone Camp to the Channel along the left edge of an expanse of shingle, dotted thickly with holly, broom, and wild briar bushes. A line of railway, for some distance double, running down to the extreme targets, 3,100 yards from the camp, and about 300 yards from the sea, forms a through connection with the S. E. Railway line at Lydd Station, and affords the greatest convenience to parties for practice and fatigues. A steam engine and four to six trucks under the R. E. were used daily. Until the arrival of this detachment a steam sapper was the only locomotive, and by its rough and jerky motion seriously damaged the line in places, laid, as it is, on such unstable ground. A hand-trolley, which held six comfortably, proved very handy for officers visiting the ranges during the practice.

4/1 Eastern Division, R.A., commenced their elementary (recruits) practice on the 23rd June, firing 16 rounds from the 40-pr. R.M.L. and 8-inch R.M.L. howitzer at 1040 yards range, the targets being wooden, 9 feet square.

2/1 London Division carried out similar practice on the following day. Elementary practice with the 6·6-inch R.M.L. gun on hydro-pneumatic carriage, 6·6-inch howitzer and 25-pr. followed on the 25th, 28th, and 29th by both batteries, 4/1 Eastern having fired a total of 75 rounds, and 2/1 London, 40 rounds.

Saturday in each week was occupied in striking the camp; the tents and the ground near them were thoroughly cleaned, and the tents were re-pitched after an interval.

During this and the subsequent practice, the apparent results of the fire were judged and signalled by flags to the battery by an "observing party," under an officer, sent out to the right front at a distance

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Date.	Nature of Gun.	Nature of Practice.	Nature of fire.	Time.	No. of rounds.	Projectile.	Charge.	Fuze.	Range.
									yards.
24th June.	8-inch howitzer.	Elementary.	Frontal. High angle.	11.30 a.m. to 12.45 p.m.	8	Plugged common shell. (water).	11½ lb. P.	None.	1160
	40-pr. R.M.L. Overbank.		Frontal. Direct.		8		7 lb. R.L.G.[2]	None.	1160
26th June.	6·6-inch R.M.L. howitzer.	Elementary.	Frontal. High angle.	4.15 p.m. to 5 p.m.	8	Plugged common shell. (water).	3 lb. R.L.G.[2]	None.	1600
29th June.	25-pr. R.M.L. Overbank.	Elementary.	Frontal. Direct.	9.45 a.m. to 11 a.m.	8	Plugged common shell. (water).	4 lb. R.L.G.[2]	None.	1150
	6·6-inch R.M.L. gun on H.P. carriage.				8		25 lb. P.	None.	1150
30th June.	*40-pr. R.M.L. Overbank.*	1st Series.	*Frontal. Direct.*	*9.45 a.m. to 12 noon.*	*12*	*Common shell filled.*	*7 lb. R.L.G.[2]*	*Percussion R.L. Mark II.*	*1200*
	25-pr. R.M.L. Overbank.	Service.	Oblique. Direct.	Ditto.	12	Common shell filled.	4 lb. R.L.G.[2]	Percussion R.L. Mark II.	1200
1st July.	*8-inch R.M.L. howitzer.*	1st Series.	*Frontal. Curved.*	*9.45 a.m. to 12 noon.*	*12*	*Common shell filled.*	*11½ lb. R.L.G.[2]*	*Direct action.*	*1200*
	6·6-inch R.M.L. gun on H.P. carriage.	Service.	Frontal. Direct.	Ditto.	12	Common shell filled.	25 lb. P.	Percussion R.L. Mark II.	1200
2nd July.	*6·6-inch R.M.L. howitzer.*	2nd Series.	*Oblique. High angle.*	*11.15 a.m. to 12.30 p.m.*	*10*	*Common shell filled.*	*3 lb. R.L.G.[2]*	*Direct action.*	*1600*
	Ditto.	Service.	Ditto.	1.30 p.m. to 3 p.m.	10	Common shell filled.	Ditto.	Ditto.	1600
5th July.	*6·6-inch R.M.L. howitzer.*	3rd Series.	*Oblique. High angle.*	*11.30 a.m. to 1.15 p.m.*	*15*	*Common shell filled.*	*2 lb. R.L.G.[2]*	*Direct action.*	*1600*
	Ditto.	Service.	Ditto.	2.30 p.m. to 4.30 p.m.	15	Common shell filled.	Ditto.	Ditto.	1600
6th July.	*6·6-inch R.M.L. howitzer.*	5th Series.	*Oblique. High angle.*	*10 p.m. to 10.30 p.m.*	*5*	*Common shell filled.*	*2 lb. R.L.G.[2]*	*Direct action.*	*1600*
	Ditto.	Service.	Ditto.	11.15 p.m. to 12 midnight.	5	Common shell filled.	Ditto.	Ditto.	1600
6th July.	*6·6-inch R.M.L. howitzer.*	4th Series.	*Frontal. High angle.*	*10 a.m. to 10·15 a.m.*	*13*	*Common shell filled.*	*2½ lb. R.L.G.[2]*	*Direct action.*	*2100*
	Ditto.	Service.	Ditto.	11.30 a.m. to 12.30 p.m.	12	Common shell filled.	Ditto.	Ditto.	2100
8th July.	25-pr. R.M.L. Overbank.	Competitive.	Frontal. Direct.	10.30 a.m. to 1.15 p.m.	43	Plugged common shell. (water).	4 lb. R.L.G.[2]	None.	1000

Practice carried on by 2/1 London, in Roman. Practice carried on by 4/1 Eastern, in *Italics*.

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Apparent results signalled by Observation Party to right front of battery.

Range Party in Splinter-Proofs 150 to 300 yards from the target recorded the effects of the fire.

Means of judging effect.	Object of fire.	Target.	Effective rounds.	Result.
650 yards.		Wooden target, 9 ft. square.	Direct hits; Nos. 2, 3, 11. Ricochets; Nos. 7, 10, 14, 16.	Round No. 7, target down.
700 yards.		Wooden target, 9 ft. square.	None.	Practice variable.
500 yards. | 400 yards. | 600 yards. | 850 yards. | 850 yards.		Wooden target 9 ft. square.	7 direct hits and 2 ricochets.	Practice good.
	Dismount gun.	*Dummy gun in 2-gun screened battery.*	*Nos. 5, 7, 8, 10, 11 and 12.*	*These shots struck superior and exterior slopes.*
	Ditto.	Ditto.	Nos. 5, 8 (blind) 10.	Interior revetment of traverse and exterior slope damaged.
	Breach parapet Dismount gun.	*Dummy gun in 2-gun screened battery.*	*Nos. 1, 2, 3, 5, 6, 8 9, 10, 11. Also 4, 12, grazed.*	*Channel 10 ft. to 15 ft. wide, 3 ft. to 5 ft. deep, cut through parapet. Gun dismounted.*
	Ditto.	Ditto.	Nos. 4, 5, 6, 9, on parapet.	No. 5 tore away half of front revetment of emplacement. Parapet fairly cut down.
	Breaching Concealed revetment.	Concrete wall, 8 ft. high, with covering mass 11 ft. 6 ins. high.	*Nos. 3 and 5.*	*Half of wall demolished to 3 ft. 6 ins. from crest. No. 10 through gap of No. 3.*
	Ditto.		None.	Nos. 2, 3, 4, 5, 9, 10, struck slope of the covering mass. No. 10 blind.
	Breaching concealed detached wall.	Concrete wall, 2 ft. high, with covering mass 11 ft. 6 ins. high.	*None.*	*Nos. 7, 10, 11, struck the covering mass. Remainder fell "over."*
	Ditto.		No. 5 on top of wall.	Breach 9 ins. deep 2 ft. wide on top of wall. Nos. 9, 14, 15 struck covering mass.
	Ditto.	*Ditto.*	*No. 4.*	*Struck right corner of the wall.*
	Ditto.	Ditto.	None.	No. 3 struck one gabion off crest of covering mass.
1125 yards.	*Destroying overhead cover.*	Blindage of earth and timber, 36 ft. by 21 ft. Ground dimension.	*Nos. 7 and 9.*	*No. 7 formed deep crater on exterior slope. No. 9 made a gap in the rear revetment.*
	Ditto.		No. 12.	Burst on exterior crest.
		Wooden target. Bull's-eye. 4 ft. diameter.	Nos. 12, 18, 25. Bulls-eye.	10 direct hits. 2 ricochets.

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roughly equal to half the range and 200 or 300 yards from the line of fire.

A "recording party" also under an officer, watched the fire from splinter-proofs in a line with, and some 200 yards from the target. This officer observed accurately and noted the effects of each shot; when the wooden targets were damaged, or the points of burst required close inspection, he lowered his flag, a signal which was imitated in the battery; on this, he carried out his object.

The system of observation from a flank, though practised under conditions infinitely better than could be hoped for on service, showed many cases when the judgment was very incorrect; this was chiefly seen during the firing at the "screened wall" on the morning of the 5th July. Shots falling to the extreme left some distance "over" appeared most reasonably to the party on the right flank to be "range," or nearly so, and were so signalled to the battery.

The service practice began on the 30th June with the five pieces already mentioned, and continued uninterruptedly to the 6th July. The 6·6-inch howitzer, which was chiefly employed, proved itself to be little inferior to the 8-inch howitzer in its destructive effects, and was very accurate.

Each piece of the siege train was used strictly for its proper purpose as on active service; it may be noticed that now the 6·6-inch R.M.L. gun on hydro-pneumatic carriage formed an important unit, which was absent at Chatham, while the 6·3-inch howitzer was discarded as obsolete. The hydro-pneumatic mounting worked admirably throughout. The fire of the high velocity guns was shown to be harmless in its effects against comparatively small targets, when compared with the entire destruction wrought by the howitzers.

This was well seen in the practice of the 1st July with the 8-inch howitzer and 6·6-inch gun on hydro-pneumatic carriage. At the short range of 1200 yards the howitzer cut down the whole parapet protecting the gun emplacement, and dismounted the dummy gun; while the gun, which was the target of the 6·6-inch R.M.L. gun, might still have been worked with fair cover for the detachment. The practice of 4/1 Eastern on the 2nd, and of 2/1 London on the 5th (morning) was particularly interesting and good.

The five rounds fired by each battery on the night of the 5th, were fairly satisfactory; 4/1 Eastern scored the only direct hit, which may be partly explained by the fact that it was then not quite dark. At about 10.30 p.m. a heavy fog crept up from the sea, rendering the "reverse laying" of the howitzer upon a banderole in rear very difficult. Great delay was caused by the uncertain working of the signallers with lanterns, the light from which was scarcely visible at the distance—about 1500 yards. It may here be mentioned that the bull's-eye lanterns supplied for sighting and laying by night were not quite suitable.

The "service practice" will be found in detail, with short and only imperfect descriptions of the results, upon the accompanying table. The 25-pr. on overbank carriage was found to jump excessively. One

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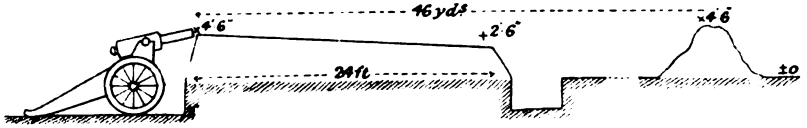
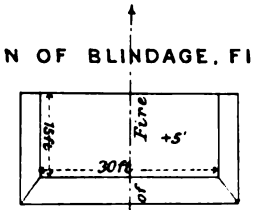
PROFILE OF TARGET-SCREENED BATTERY, FIG. I.



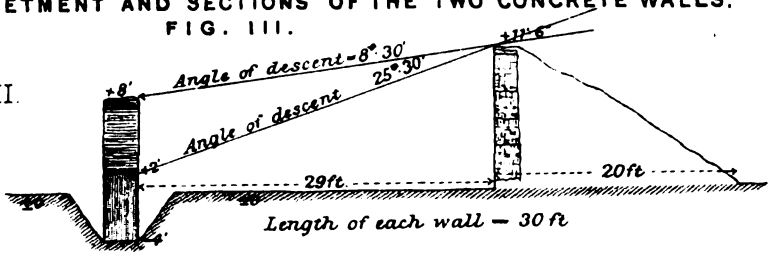
PLAN OF BLINDAGE, FIG. II.



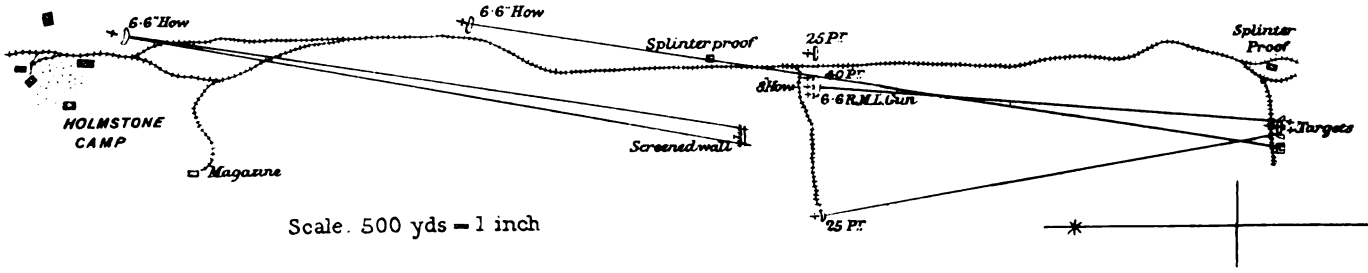
Scale 32 ft = 1 inch

PROFILE SHEWING REVETMENT AND SECTIONS OF THE TWO CONCRETE WALLS. FIG. III.

Scale for Figs I. & III.
16 feet = 1 inch.



ROUGH PLAN OF THE HOLMSTONE RANGES, FIG. IV.



Scale. 500 yds = 1 inch

Vincent Brooks Day & Son. Lith.

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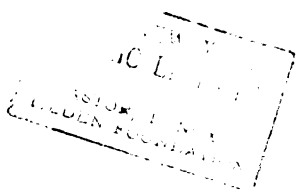

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or two of the earliest shots, laid at an elevation corresponding to 1150 yards, ranged 80 to 120 yards "over."

In the competitive practice of 2/1 London with this gun on the 8th July, the shock on discharge of the first few rounds broke off the heads of the screws fixing the patch of the elevating gear to the carriage, rendering it so shaky that great care was necessary in successfully firing the total of 43 rounds, without rendering the gun temporarily unserviceable.

The squally weather lasted only a few days, giving place to the brightest and warmest perhaps experienced this summer. Large straw hats were served out to the batteries, and worn regularly. The heat of the sun often produced most curious mirages on the wide stretches of shingle, and the glare wearied the eyes in laying on distant objects, or in estimating distances.

Carbine practice, bathing parades, and cricket matches filled up the afternoons and evenings. The amusements also included a concert in the Recreation Room, and two even more successful "camp fires," which were kindly sanctioned by Colonel Hume, the Camp Commandant. The officers and the men of the Royal Artillery, and also of the Royal Munster Fusiliers, who lay alongside in the Infantry Camp, combined to make the proceedings pass off thoroughly well. On the 10th of July, the batteries marched out of camp, led by the band of the Fusiliers; a little later the trains carried them off, amidst the warmest parting cheers—4/1 Eastern to Portsmouth, and 2/1 London to new quarters in Woolwich.

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THE GARRISON GUNNER.

"A man so various, that he seems to be
"not one, but all mankind's epitome."—*Dryden.*

BY

CAPTAIN E. NASH R.A.

Amongst all the various types of soldiers perhaps there is none so distinct as the British gunner, though in the present day he is certainly less marked than formerly. His scientific training has induced a habit of reasoning; the variety of his duties has made him ready in resource; his heavier work has made him slower of movement than men of other arms. He is usually slow of speech, weighing his words. But these characteristics apply more especially to the garrison gunner; and they would, no doubt, became more highly pronounced were he confined to heavy fortress work and not called upon to perform a variety of duties, in any one of which, with the short period of service at his disposal, he could hardly expect to become proficient.

It is not, however, intended here to make a psychological study of the garrison gunner, but rather to bring to notice two special features in connection with his present employment. These are; (1), the variety of his duties, and (2), his increasing importance.

During the period which elapsed between the so-called birth of the Regiment (1716) and the year of its present triple formation (1859), England was adding to her Empire in all parts of the world. Herself in jeopardy, severely threatened with invasion, sometimes standing alone against the oppressor of nations, secure only in the prestige of her great naval power, she yet found means for carrying out offensive operations, gaining territories for future colonies and annexing native states as dependencies. Her best defence seems to have been found in offence. But in all these enterprises, often undertaken with most meagre preparations, sometimes carried out with curious half-heartedness, and yet resulting in so great ends, the true character of the British soldier was eminently displayed. No greater meed of praise was bestowed during all these years than fell to the lot of the British gunner. The history of the Regiment fairly bristles with deeds of valour and high encomiums. The well-known words of the French General Foy are but a type of many others recorded from the mouths of English and foreign generals.[1] In the remembrance of the hardships undergone, the gallant acts performed during that bright period,

[1] "Les cannoniers Anglais se distinguent entre les autres soldats par le bon esprit qui les anime. En bataille leur activité est judicieuse, leur coup d'œil parfait, et leur bravoure stoïque."

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the garrison gunner must be allowed to participate. He may read of Minden, the Peninsular and Waterloo, of the sieges of Louisbourg and Sebastopol, and claim his share in the memory of these; whilst he recognises work more akin to his own in the brave defence of Minorca and Gibraltar's great siege.

That high scientific attainments were recognised as essential even as early as 1744 may be seen from a letter from the Board of Ordnance, dated 24th February of that year. "The qualifications of artillery officers" it runs "are not acquired by practice only, but are the result of long study and application. They must be proficient in several sciences and masters of several arts, which is not required from other officers." If such qualifications were deemed necessary in the employment of, what seems to us, the simple material of those days, how much more essential have study and application become now!

If, then, the garrison gunner were confined to-day to his more legitimate work in connection with the defence of a fortress, he is even then hardly likely to complain of want of variety in his duties. How simple appear those of the field artilleryman in comparison! He has only one type of gun to master, a very limited variety of ammunition, which is always packed in the same manner, always supplied by the same machinery. The garrison gunner has to deal with no such enviable monotony. Each new battery he enters displays a new type of gun, entailing a variety of ammunition puzzling in its details. No two store-rooms are packed in the same manner, and the supply of ammunition becomes complicated beyond conception. But until he has mastered the three great essentials in the conduct of a fight, namely, the power of his guns, the supply of ammunition, and the nature of the probable objective, he is in no position to make the most of what is placed in his charge. And yet a knowledge on each one of these points can only be acquired by careful and constant study. In one matter only may he be said to have an advantage over the field gunner: he acts always on the defensive from a fixed position and reaps the benefits which always attend such action. He can lay his plans beforehand, he can recognise all the movements which an enemy is likely to make, and arrange to meet them, whilst his ranges are measured and marked.

Now to learn all this is, indeed, the special duty of the officer, but having learnt it he will not fail to impart all the necessary principles to his men. For the latter, the manipulation of the various natures of guns and ammunition will be always the first requisite; later some wider instruction in technical details is certainly required. As long as it is necessary to shift batteries constantly from place to place, thus rapidly introducing novel combinations, the time for thorough instruction is all too short. But there is a worse process, and one very liable to destroy the efficiency of a garrison battery—one which would be known in the medical profession as "transfusion"—the taking of the life-blood from one to give to another. I fancy I hear the shriek of a battery commander now, as the official mustard-plaster,—Army Form B 91—is applied to him, relieving him of his best men for the benefit of a deficient field battery.

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It has been said that if the garrison gunner were confined solely to fortress defence work his duties would be far from wanting in variety. That he is not so confined is well known. All siege work in the field belongs to him, as well as the manning of several mountain and heavy batteries. He has, on occasions, passed through many and great vicissitudes; how many and how great may be seen from an example in the note below.[1] Out of a total of 101 garrison batteries there are, at present, 72 employed in coast defence in England and the Empire, whilst the remaining 29 are disposed as follows:—10 mountain batteries, four heavy batteries and 15 inland garrisons, 12 of the latter being in India or Egypt and three at Woolwich. The chance, therefore, of a man being employed in other work than coast defence during peace is in the proportion of $\frac{29}{101}$ or about 1 to 3½.

The work in any one of these 29 batteries is light in comparison with that required for real proficiency in the remaining 72, but the chances of active employment in these latter are at present, fortunately for the Empire, more remote. But no officer can feel satisfied, nor can he afford to sit idle, as long as he believes himself incapable of using the material placed in his hands to the best advantage, or until he is convinced that, come what may, the lives of his men, who so implicitly trust in him, shall not be lost through any ignorance of his own. It is for this reason that he cries aloud for all the means which will simplify his labours and add elements of success to his work; for this reason he looks with anxious eyes to the position-finder, to the development of electric light, to proper arrangements of obstacles; for this reason he asks for improved communication between forts and concentration of batteries, with such transport available as may ensure his being able to man a fort completely for practice, and thus recognise its deficiences, and, while there is yet time, prepare his plans for an active defence.

Let us pass now to the question of the increasing importance of the garrison gunner as a fighting unit. It is here maintained that his chances of active employment are daily becoming greater. During the 18th century and up to the end of the American war (1783) the operations conducted by England consisted chiefly in offensive coast descents and land sieges, all of which added considerably to her possessions. Then followed the Peninsular war, the campaign of 1815 and the Crimea, these enterprises being undertaken with a view to maintaining the balance of power in Europe. Minor and more recent operations, conducted far from the base, such as those at the Cape, the occupation of Egypt, the annexation of Upper Burmah, all wars of policy, not of aggrandisement, will result in a strengthening of British

[1] 1876. Secunderabad. Heavy battery. Two 24-prs., one 8-in. howitzer, two 8-in. mortars and two coehorns, nine elephants and nearly 300 bullocks, with 24 wagons.
1877-79. Burmah. Mountain battery. Six 7-prs., 22 elephants and 4 ponies.
1880. Aden. Mountain battery. Four 7-prs. Camels.
1881. Pembroke Dock. Coast defence.
In these five years one battery which performed this feat changed its dress completely twice and its title twice.

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influence and a consolidation of Imperial interest. The time has now arrived for a closer binding of Imperial ties.

Steam and the electric current have brought the colonies as near to England as Scotland was a few years ago, and have rendered possible the transformation of the United Kingdom into a United Empire. The lines of communication of such an empire are the ocean highways; the posts upon these lines are the coaling stations and docks. The security of such posts is absolutely essential to the maintenance of the line. Security is obtained by means of coast defences, and the first man required in this emergency is the garrison gunner.

It may be doubted whether a single foreign power, or even two combined, could now carry out such a blockade of England as that proposed, and so nearly put into execution by Napoleon in 1805; but certainly immense and lasting injury could be done to our trade,—an injury which could only be checked by the successful employment of our navy. Every ship, then, must be released; not a single one being kept for the defence of British or Colonial docks and coal-depôts. These must be self-supporting.

In case, then, such a crisis should arise (and we cannot indeed afford to neglect the study of such a contingency), it is probable that the first step taken by an enemy would be a series of violent assaults on our principal coaling-stations either at home or abroad; it matters little which, for the loss of even one of these would seriously paralyze the action of our war-ships.

Is our garrison gunner to be subjected to battalion drills such as he first experienced under Colonel Bradford in 1746, or is he to be made proficient in the use of his true weapons? Are we to depend upon the Navy for co-operation, and if so is it possible that they might fail us as at Walcheren? Can we ensure such a concerted action with the Engineers, who lay the passive obstacles of mines and booms, and work our electric-lights, that all may be in harmony, working on a pre-arranged plan with all the elements of success?

A true answer to all these questions should be the result of such practical experiments as those carried out lately at Milford Haven. But, if a negative reply must be given to them, then there is only one alternative, and that is—to give our garrison gunners a still further variety of duties, and form them into a Coast Brigade, whose duties should combine the manipulation of the whole means of coast defence, including torpedoes and mines, passive obstacles, and boats to guard them, electric lights and artillery fire.[1]

All this applies with equal, perhaps greater force, to our colonial

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[1] An idea of this kind may be noted in General Boulanger's scheme for the re-organization of the French army. Three articles quoted from the *R.E. Journal*, July 1886, are as follows:—

"To hand over to the Engineers the batteries of Garrison Artillery."

"Engineers to consist of 12 regiments, each regiment of three battalions, of four companies each."

"Of the 12 companies of each regiment, eight to be companies of gunners and four companies of sappers and miners."

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gunners, where there is at present but a small naval force,[1] and no force instructed in the science of torpedoes and submarine mines.[2]

Finally, let the garrison gunner remember that his true Goddess is "Armed Science." To her all his vows must be paid,—he is her true votary; and let none of us forget that if England should be prevented, by a combination of circumstance, from carrying out that best of defensive operations, namely, an offensive campaign, then it is upon the garrison gunner that the first blow must fall. And if his heart should fail him in devotion let him read again the words of Canon Kingsley:—[3]

"The two classes which will have an increasing—it may be a preponderating—influence on the fate of the human race for some time, will be the pupils of Aristotle and those of Alexander; the men of science and the soldiers. . . .

"They, and they alone, will be left to rule, because they alone—each in his own sphere—have learnt to obey. . . .

"The finest type of civilized man which we are likely to see for some generations to come will be produced by the combination of the truly military and the truly scientific man."

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[1] The Colonies of Australasia have a small local naval force, viz., the *Protector*, a cruiser, in South Australia; the *Cerberus*, turret-ship; *Victoria* and *Albert*, steel gunboats; the *Chilaers*, first-class torpedo boat and the *Napean* and *Lonsdale*, second-class torpedo boats, at Victoria; the *Wasp*, gun-boat, and the *Mavis*, *Palerma*, and *Gayandah*, sloops, in Queensland; and a second-class torpedo-boat in Tasmania."

[2] Torpedo companies may, under the Militia Act, be raised in Canada, but there are none in existence. And yet Quebec, Montreal, and many ports on the lakes are particularly open to attack and would be easily and efficiently defended by these means.

[3] Spoken at R.A. Institution, 3rd October, 1871.

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REPLACING DISABLED HORSES IN A TEAM.

BY

MAJOR G. R. GAMBIER, R.H.A.

In No. 4, Vol. XIV., November 1885 number of the R.A. Institution Papers, was published my method for replacing disabled wheel horses on a different plan from that detailed in the "Manual of Field Artillery Exercises;" as I have, since writing upon this subject, had considerable practice, and have much improved upon the plan originally proposed, I wish now to bring to notice what these improvements are. At the word "*Wheel horses disabled,*" unhook the team and send away the wheel horses, place any one of the centre, lead or detachment horses (whichever is best suited) between the shafts, take a drag rope and hook it into itself, and make a loop at either end to allow of the shafts being run through, the rope is then placed over the saddle, making a perfect back band; take another drag rope, fasten the hook into the breeching loop on the near shaft, pass the end under the horse's croup, and take one half turn or hitch round off shaft in *front* of back band loop, and pass the spare end (of which there is ample) under the horse, and make fast to the near shaft. By these means you have back band, breeching, and belly band made out of two drag ropes; the traces are shortened in the usual way round the footboard and splinter-bar, detachment horses are hooked in to complete the team. I may state that the detachments of my battery constantly execute this manœuvre in less than four minutes from the time of giving the word of command "*Wheel horses disabled,*" to the time the six guns move off at a gallop, without a single set of wheel harness in the battery, some sub-divisions do it in less than three. I have introduced a plan also for draught when the off or near shaft is broken. Suppose the off shaft is disabled,—First unhook and withdraw it, then take a collar chain, make one end fast to the loop on the inside of the hame (to which the trace is attached) pass the other end round the near shaft, with a clove hitch, then pass it up to the loop on the off horse's collar and make it fast—do the same with the other collar chain, beginning with the off horse and making it fast to the head collars. By this means you have an admirable pole draught, which I have proved practically at a gallop to be most efficient. The near shaft is passed through the near loop of the back band, so that if the chains broke (which I have never found occur) the shaft should not fall to the ground. If the near shaft is disabled, the off shaft must be shifted to the place for its reception under the splinter bar, and a swingletree attached to the outer loop of the same. As a proof of the celerity with which a gun can be removed after a shaft has been broken, by turning the near shaft into a pole, I may mention that E/A, R.H.A., at the word "*Off*" or "*Near shaft disabled,*" can move off at a gallop with pole draught in less than two minutes.

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EXPERIMENTS AT BUCHAREST.

BY

MAJOR D. D. T. O'CALLAGHAN, R.A.

AND

CAPTAIN G. S. CLARKE, R.E.

THE general idea of the defences of Bucharest appears to be to create a place of arms in which the whole military strength of the kingdom can be gathered. It is recognized that the military position of Roumania is distinctly dependent; but the absence of any permanent defences practically prevents the choice of an ally. The Eastern frontier is so open that Bucharest could be occupied by a Russian army in a few days. It is argued, therefore, that by the creation of a place of arms, time would be gained to enable any power to give practical effect to an alliance. Bucharest was selected as the centre of the wealth and commerce of the country, as well as the junction of its railways. The position possesses no natural advantages, and the opinion has been expressed that a second place of arms should at least be formed on the Kronstadt Railway among the southern spurs of the Carpathians.

The decision to defend Bucharest having been taken, General Brialmont was asked to furnish designs and advise generally upon the scheme to be adopted.

As far as could be gathered, the following are the principal features of his proposals:—

The main defence is to consist of 18 large forts, at about 4000 metres interval, supplemented by intermediate batteries.

The forts are to have earth scarps and a detached wall flanked by counterscarp galleries with three embrasures—two firing in front and one behind the wall. The counterscarps are to have arched counterforts. The detached wall is to be protected from projectiles grazing the crest of the glacis, with a descent of 1 in 3. On the flanks, it is considered that the wall is sufficiently protected if it cannot be hit at an angle exceeding 45 degrees. In front, there will be a second glacis, covering wire entanglements and other obstacles. On the flanks, wing batteries and rifle trenches will be provided. The parapets are to be constructed of sand, with a layer of vegetable mould on the top, the exterior slope being about $\frac{3}{2}$.

An interior reduit contains three turrets or cupolas, and a battery for four howitzers. The latter are to have central pivots and hydraulic

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buffers. Between each adjacent pair there is a hollow traverse, capable of containing the howitzer. At the back of this chamber there is a small ammunition store.

General Brialmont, in his work "*La Fortification du temps présent*," expressed an opinion in favour of turrets for land defence, and reproduced the designs of the St. Chamond firm, including a project for a moveable shielded battery running on rails laid behind a parapet. It was decided, therefore, that a competitive trial should take place between the rival firms of Grüson and St. Chamond, from which it was expected that data leading to a definite decision would be obtained. The total cost of the experiment was nearly £40,000; but as yet no final decision as to the armament of the forts seems to have been taken. For the armament of the intermediate batteries on the fronts most liable to siege, rifled mortars fixed in a spherical mass, pivoting under a horizontal shield, and thus presenting no open port, according to a design of the Grüson firm, appear to have been recommended. As to the ditch-flanking armament no decision has been arrived at; but some form of machine or quick-firing gun will doubtless be adopted.

Three of the new forts only had been commenced at the time of our visit, situated as follows :—

1. Chitella Fort on the road and railway leading to the Austrian frontier at Kronstadt.
2. On the road to Mogosoie, 2 kilometres from Bucharest, and due north of the "chaussée."
3. At Goulaqui, on the west of the town, between Chitella and Cotroceni.

Of these, the two first named are the most advanced, the ditch excavation being nearly completed.

Diary of Experiments.

18*th December*.—Inspection of cupolas. Fired from both cupolas with "projectiles fictives."

19*th December*.—Fired 10 salvoes for accuracy.

21*st December*.—French turret fired 25 salvoes, and 22*nd December*, German cupola fired 25 salvoes for rapidity and accuracy.

23*rd December*.—Continuation of practice for accuracy. Each cupola fired 10 rounds.

24*th December*.—Practice at a target suddenly presented. Each cupola fired 3 salvoes.

26*th December*.—Practice at French turret with de Bange 155^{mm} and Krupp 15^{cm} guns; 42 rounds fired.

27*th December*.—Practice at French turret continued; 9 rounds fired. Practice at German turret with de Bange 155^{mm} and Krupp 15^{cm} guns; 27 rounds fired.

Practice for accuracy from French turret; 5 rounds fired.

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28*th December*.—Practice continued; 58 rounds fired. Practice for accuracy from German cupola; 6 rounds fired.

29*th*, 30*th*, *and* 31*st December*.—Practice at cupolas with 21^{cm} Krupp rifled mortar; 14, 56 and 44 rounds respectively.

1*st January*.—Ditto; 50 rounds fired.

2*nd*, 3*rd*, *and* 4*th January*.—Dismounting guns in cupolas, and their replacement by dummies, and construction of siege battery at 50 metres.

5*th January*.—Practice at embrasures of both cupolas; 11 rounds fired.

7*th January*.—Practice at glacis plate of French turret. 20 rounds fired.

8*th January*.—Practice at glacis plate of German cupola; 21 rounds fired.

11*th January*.—Practice for breaching German cupola; 50 rounds fired.

14*th January*.—Practice for breaching both cupolas; 36 rounds fired.

15*th January*.—Ditto ditto French turret; 19 rounds fired.

16*th January*.—Guns remounted in cupolas.

17*th January*.—Practice for accuracy and rapidity, German cupola; 20 salvoes fired.

20*th January*.—Practice for accuracy and rapidity, French turret; 21 salvoes fired.

22*nd January*.—Practice against a wrought-iron plate of German cupola; 21 rounds fired.

23*rd January*.—Fired 7 rounds, filled and fuzed shell, from 21^{cm} Krupp rifled mortar; for effect in soil.

GERMAN CUPOLA.

General Description.

The pit or emplacement consists of a single circular chamber 19 ft. 6 ins. in diameter, with brick walls about 5 ft. thick. The floor level is 3 ft. 6 ins. below the natural surface of the ground. The pit is entered by steps through a door 5 ft. wide. There are 14 recesses, 3 ft. high by 2 ft. broad, and 18 inches deep, evenly spaced round the interior wall. Each recess has one shelf and can hold altogether 24 projectiles, so that a total of 168 rounds for each gun can be stored in the emplacement.

The glacis plates rest on the top of the wall which ends at the level of their lower surface. Outside these glacis plates, there is a mass of concrete 9 ft. thick, measured along the superior slope from their inner

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edge. The exterior slope of this concrete is 35 degrees, and in front is a thick parapet of sand on the side which was attacked. The roller path (*a*) and the gunmetal training arc (*b*) are fixed to the inner top angle of the wall. The socket of the screw pivot (*c*) is bedded in concrete—not in wood, as shown in Plate I.—and there is a false floor boarded over except in the centre, where the fixed internal toothed wheel of the traversing gear and the pivot are left bare.

There was ample space for moving about freely in the emplacement, and for the operations of loading and traversing.

agazine ccomoda- on. No special magazine accommodation was provided, and the ammunition was brought into the gun pit as required, no large amount being ever kept there during the course of the experiments.

escription Cupola. The cupola consists of two armoured portions—(1) the glacis plates set in concrete and forming a complete annulus round the pit; (2) the curved shield, free to turn on a central pivot, and covering the two guns and mechanism.

lacis. 1. The glacis, or *avant cuirasse*, consists of eight cast-iron blocks or segments set in concrete, and formed as shown in Plate I. Each block is provided with eyebolts cast into it for purposes of manipulation, and has ribs at the ends. The outer faces of these ribs have projections which fit into corresponding recesses in the adjacent blocks. The joints thus formed are run with zinc. The two rear blocks which were to be attacked, had central ribs in addition, apparently with a view to give them greater strength. The total weight of the glacis *ring* is 70 tons, and its internal diameter 5·93 metres (19·45 ft.)

2. The curved shield consists of six segmental side plates and a hexagonal roof plate. The front plate which is pierced for the two guns, as well as the plates on either side of it, are of wrought-iron. The three remaining side plates are compound. The thickness of all the plates is 20^{cm} (8 in.) The total weight of the shield is 46 tons. The curvature of the plates is such that the angle of impact of a projectile striking them horizontally can never exceed 25 degrees. The portion of the front plate surrounding the two gun ports is strengthened by swelling out the metal round the openings at the top and sides, as indicated in the section, Fig. 1, Plate I. The wrought-iron plates are bent by hydraulic machinery. The compound plates are made on Mr. Wilson's principle by running the molten steel on to their upper surface. The plate is made up of three qualities of metal as follows:—7^{cm} hard steel face, 3^{cm} soft steel, 10^{cm} wrought-iron. The mass is then re-heated, bent by hydraulic power, and subsequently annealed. The cost of the plates is materially enhanced by the great waste of metal incurred by cutting off the corners in shaping them. The plates so made are united to form the shield by being bolted to an inner skin composed of two layers of wrought iron-plate, each 0·8 in. thick. These layers are rivetted together, and through them pass five bolts of steel, the female screws of which enter half through the main armour plates. The bolts are rivetted up from the inside. The side armour plates are further held together at each junction by one steel

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wedge of the form shown in sketch, and abut against the central hexagonal plate, but are not keyed to it.

The most striking principle in the design of this cupola is the method of supporting the shield. The whole weight of the moveable portion of the structure is taken on a central pivot (*e*, Plate I.) 8 ins. in diameter. The pivot (*e*) is screwed into the socket piece (*c*), and the collar (*f*) is keyed on to it. This collar is provided with a worm wheel on its outer circumference, which engages an endless screw (*d*). By means of a ratchet lever, the worm wheel can be turned, thus raising or lowering the pivot, and with it the whole superstructure. The total vertical movement which can be given is 6 ins., and this allows the shield to be lowered down upon the glacis plates or elevated into the firing position. The whole structure is thus free to rock on the rounded top of the pivot (*e*), but the lower edges of the shield are prevented from coming in contact with the glacis by legs (*o*) resting on trucks running on a circular racer (*a*), and set in journal boxes provided with strong voluto springs. These springs thus serve to cushion the vibratory motion set up by the force of recoil, or by the impact of projectiles. The maximum movement measured at the top of the shield is stated to be only about $2{\cdot}5^{cm}$ or 1 in., but appeared to be considerably greater. Pivoting arrangements.

The whole stress of recoil is transmitted to the general structure of the turret by a pair of vertical arcs (*p*) in rear of the breech of each gun. A ring (*g*, Plate I.), is shrunk on to the chase at a short distance from the muzzle, having trunnions which rest in recesses formed in the inner skin at the sides of the ports. These recesses are open in rear, so that they allow the trunnions to pivot freely, and at the same time, by moving them a few inches to the rear, they clear the recesses when it is required to dismount the guns. In rear of the breech of each gun is a powerful capstan-headed clamping screw (*h*), by which all play between the guns and the arcs is taken up, so that hammering action is avoided. It should be mentioned that in another design the inventor avoids this clamping screw, and transmits the shock of the recoil to the main brackets of the cupola by bosses attached to the trunnions of the gun sliding in segmental slots in the brackets themselves. Recoil.

Quadrant elevation is given by graduations on these arcs, the clamping screws serving to retain the guns at the required angle. The preponderance of each gun measured about the front pivot, is slightly overbalanced by a counterpoise weight suspended by two chains, each passing over two pulleys (*l*, *m*), and attached to an iron cross-bar passing under the gun just in front of the breech mechanism, fixed in position by a steel strap.

In order to give elevation, the breech is hauled down by a chain wound round a ratchet windlass. Elevating gear.

Rotation is imparted to the cupola by a pinion (*i*) gearing internally into a horizontal toothed wheel fixed into the floor of the gun pit. Turning gear.

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The pinion is actuated by winch handles through simple bevel gearing. This gear, by means of a clutch, can be rendered available for winding in the falls of the tackle used in mounting and dismounting the guns. Four bent lever arms are attached to the legs (*o*) containing the journal boxes, and can be used, if necessary, to assist in traversing.

Close under the circular racer on which the trucks of the shield ride, is fixed a brass graduated circle, over which travels a pointer attached to the shield. This circle reads to degrees and 6-minute divisions. The maximum elevation is 25 degrees, and depression 5 degrees.

Sighting. The guns are supposed to be parallel. In rear of the centre of the top of the shield and over the medial line of the guns, is a hole sufficiently large to admit of the head of the No. 1. At the front of this manhole, and inconveniently near to the eye of the No. 1, is a hinged gunmetal sight, furnished with a deflection leaf, and free to slide up and down a slotted bar. The movement is not for the purpose of giving elevation, this being provided for as already described by the vertical arc, but for convenience in laying on objects at different levels; the sighting is, in fact, merely for line. Access to the sighting hole is provided for by a light iron ladder (*k*) between the guns.

Loading. The loading is performed at an elevation of 14 degrees, the loading position being indicated on the steel vertical arcs by a broad red band, so that the guns can at once be adjusted to it. The projectile and charge are inserted by means of a loading tray between the arcs and through the breech clamping screw, and are separately sent home by a short rammer. The guns can be loaded with equal facility at all angles of training.

Guns. The guns are 15^{cm} (6-in.) B. L. of Krupp manufacture, 25 calibres in length, and weighing about 3 tons. The common shell weighs 69·3 lbs., bursting charge 2¾ lb.; the steel shell 88 lb., bursting charge 5½ lb.; steel armour-piercing shell 86·9 lb., bursting charge 1¼ lb.

The maximum charge of the gun is 19·8 lb., cocoa powder.

Earlier Designs. The cupola above described constitutes a complete departure from the earlier designs of the Grüson firm. Starting with structures built up entirely of chilled cast-iron blocks, wrought-iron was first introduced for the roof plates. In 1882, a wrought-iron umbrella-shaped cupola, designed by Major von Schumann of the Prussian Engineers, was tried at Kümmersdorf, the design being to some extent based on the experience gained at Tegel in 1870–1, and at Maintz in 1866. The Tegel turret was made of wrought-iron, contained two guns, and nearly resembled the ordinary ship's turret. The desirability of reducing the cost and the weight led to the adoption of the non-recoil system, which allowed the protected space to be smaller in extent; while the Tegel experiment, in which projectiles striking the plates at an angle of 27 degrees produced extremely little effect, pointed to the utilization of wrought-iron in plates with double curvature. Thus the Kümmersdorf cupola was made of wrought-iron plates bent to a spherical form, with an exterior radius of 15 ft. The maximum angle at which 15^{cm} shells fired at 1000 metres could strike this cupola was 35 degrees, and the thickness of the lower edges was 7⅛ ins. At the level at which projectiles could strike only at an angle of 25 degrees,

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the thickness was reduced to 4 ins. The curved shield was formed in laminæ, two of 2 ins. thickness, strengthened internally by two 3⅛ ins. round the lower portion. The Kümmersdorf cupola contained only one 6-in. gun mounted in the same way as those at Bucharest. There were no curved cast-iron glacis plates, but instead, a vertical ring of wrought-iron 4 ins. thick.

This cupola was severely tested. A hundred rounds were fired from it at elevations between 4 degrees and 12½ degrees without injury. Eighteen long 6-in. shells were then fired at it, of which several hit the same spot, causing no damage. Seven chilled shell were then fired also without any real effect. Eight 6·7-in. (17^{cm}) chilled shell were tried, some of which striking at angles below 30 degrees produced no effect. Others, striking low down near the rim of the cupola, damaged it considerably, and proved that the protection conferred by 7⅛ ins. of wrought-iron was insufficient against the 17^{cm} gun. After firing 11 salvoes of chilled shell at 1000 metres range from four 6-in. guns, by which no satisfactory hits were obtained, the attacking battery was moved up to 300 metres, and two effective salvoes were then fired without injury to the structure.

The cupola was then attacked by the 8¼-in. (21^{cm}) rifled mortar at 65 degrees elevation, firing 176 lb. shells. Four effective hits were obtained, producing merely slight indents. The turning gear of the cupola was tried and found to be uninjured. A complete rotation was made in 36 seconds. Finally, 50 rounds were fired from the cupola gun at elevations up to 24¼ degrees, the last 25 rounds for rapidity. The rate of fire was a little less than one round per minute, and the diagram obtained was very satisfactory.

The Commission which carried out the Kümmersdorf experiments made a variety of recommendations of which the following were the most important:—

1. The shield should be made up of single thicknesses of plates instead of laminæ.

2. A flatter curvature towards the lower edge of the cupola appeared desirable.

3. The lower edge of the cupola should be better protected by being sunk below the glacis ring.

4. The employment of concrete under the shield to balance the whole structure about the central pivot should be avoided, if possible.

These recommendations, together with others, were embodied by Major von Schumann in the design of the Bucharest cupola, so that the latter may fairly be regarded as representing the results of much previous experience. The compound plates forming the rear half of this cupola were apparently introduced in accordance with the views of the Roumanian Commission.

It is to be observed that cupolas built on the principle of transmitting the recoil direct to the whole structure are termed by the makers "shield mountings" (Panzerlaffete), and that this principle was first tried at Kümmersdorf.

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Results.

18*th December*, 1885.—Two rounds were fired from each gun with full (19·8 lb.) charges at the maximum angles—viz., 5 degrees depression and 25 degrees elevation, with "projectiles fictives" weighing 90¼ lb. These projectiles were constructed to break up at the muzzle in order to avoid the necessity for clearing the range. The gear worked well throughout.

Series (*a*).

19*th December*, 1885.—Trials for accuracy—Ten salvoes at a target 10 metres by 6 metres. Range 2,500 metres. In this series five salvoes from each turret, allowed as sighting shots, were first fired.

The oscillation of the turret being considerable, and the firing being by word of command, and, therefore not always synchronous, the accuracy of the second gun was doubtless affected.

Series (*b*).

21*st December*, 1885.—Trials for rapidity and accuracy—After 3 salvoes (sighting shots), 25 salvoes were fired, the laying being corrected as in Series (*a*) by the telephoned result of each.

Total time occupied in firing 25 salvoes or 50 rounds, 2 hrs. 27 mins. 20 secs.

The times lengthened towards the end of the series. This was due to the traversing numbers, who were not relieved until after the 12th salvo, becoming fatigued.

Series (*c*).

23*rd December*, 1885.—Additional trials for accuracy, apparently ordered because the brown powder had now arrived.

Series (*d*).

24*th December*, 1885.—The practice was apparently intended for a comparative trial of the relative facility for rapidly directing the fire of the two turrets. This series must be regarded as unsatisfactory from every point of view, and so far as testing the power of firing from turrets—the object which the Committee had in view—was practically worthless.

Series (*e*.)

27*th and* 28*th December*, 1885.—(Fig. 2, p. 263).—The object of this series was to obtain 30 direct hits on two of the three compound plates forming the rear portion of the cupola, at a range of 1000 metres. To effect this 85 rounds had to be fired—viz., 27 on the first and 58 on the second day.

The cupola was turned so that the medial line of the rear centre (compound) plate faced the attacking guns.

The total number of hits obtained was 35, but of these five were *en ricochet*.

The three guns used for the attack were—

1 de Bange, 155^{mm} } of the same model as those mounted in the
2 Krupp, 15^{cm} } turrets.

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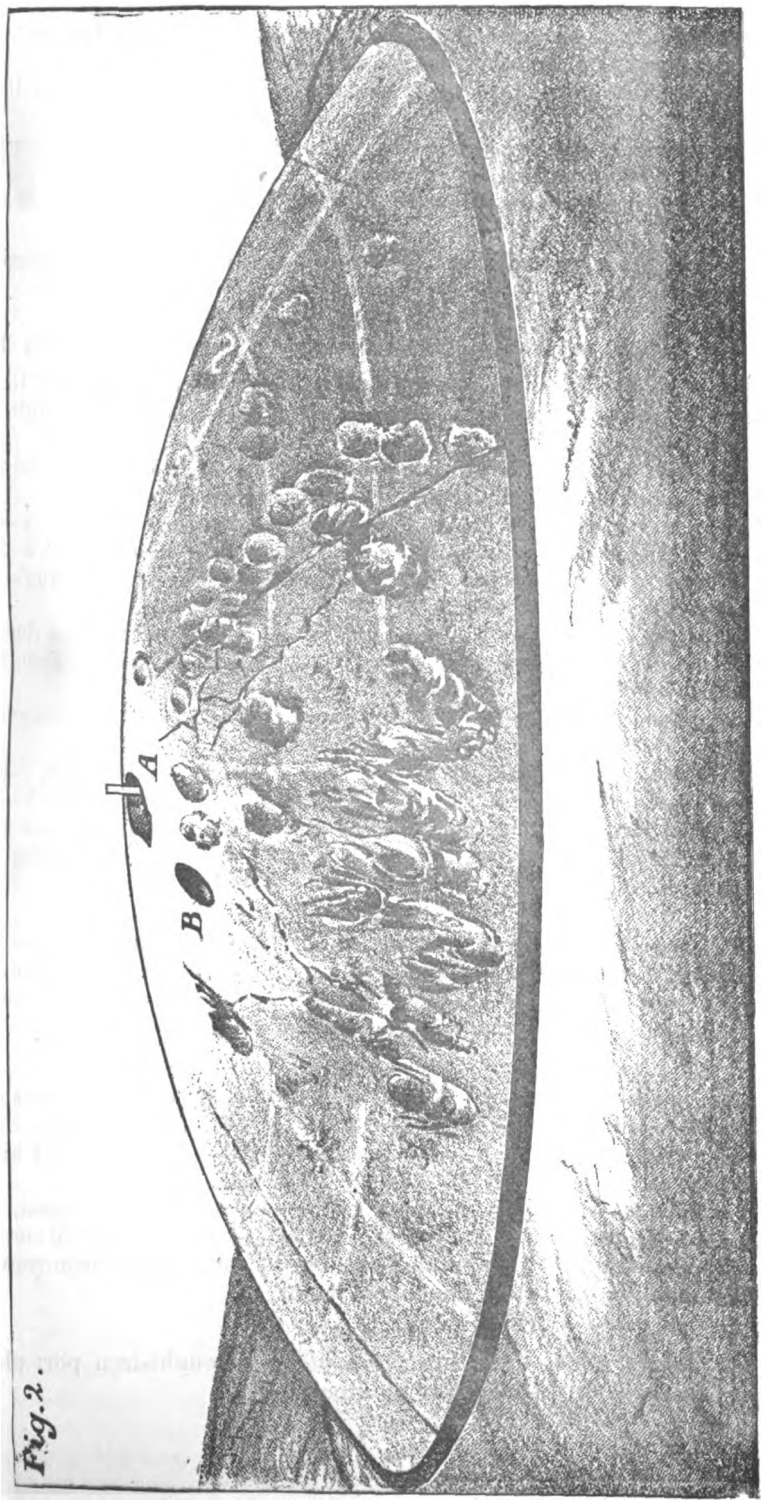

Fig. 2.

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The firing was sometimes by single rounds, varied by salvoes of two and three guns, no apparent principle being followed.

The French gun, de Bange, was mounted on a siege travelling carriage.

The German gun was mounted on a siege traversing platform of the usual Krupp pattern, on A racers.

The projectiles were all steel, of Krupp and St. Chamond manufacture.

The weights were as follows, sand being substituted for the bursting charge:—

Krupp—39 kilos. (85·8 lb.) filled; bursting charge 1·7 lb.
De Bange—40·9 kilos. (89·98 lb.) filled; bursting charge 1·7 lb.

The powder charge for the German gun was 9 kilos. or 19·8 lb. of brown prismatic powder, for the French gun the same weight of Sevran-Livry pebble.

The distribution of hits at the conclusion of the 85 rounds, and the general appearance of the turret is shown in Fig. 2, p. 263.

The general effect of single shots was to make a shallow scoop, Fig. 2, p. 263, with a maximum depth of indent of about ¾ in., and it would not appear that the depth varied according to the angle of impact with the curved surface of the plate.

A gradual cracking of the steel face of the plate took place during these rounds, but at this stage there was no actual separation from the wrought-iron.

The rotation of the cupola was in no way affected by the foregoing series.

No cracks were visible in the interior; but, at the 20th hit, one of armour bolts was sheared, and the nut and washer, weighing 33 lb., fell on the gun floor. A cast-iron spur wheel of the traversing gear was also found to be broken. One of the hand levers for turning the cupola was broken off.

Series (f).

28*th December*, 1885.—At the conclusion of the foregoing series, six rounds were fired from the guns in the turret to ascertain whether the gear was in working order. The turret had to be rotated by hand, as the broken wheel was not replaced till next day.

Series (g).

31*st December*, 1885 *and* 1*st January*, 1886.—This series was intended to ascertain the effect of high-angle fire from the 21^{cm} Krupp rifled mortar, with steel and cast-iron common shell, weighted up to 91 kilos. (200 lb.), at a range of 2,510 metres (2,745 yards).

It will be seen that the shooting on the whole was fairly good, the maximum lateral dispersion, omitting two wild rounds, being 50 metres. Two shells fell on the parapet and one on the top step of the entrance; unfortunately none struck the cupola itself.

Series (h).

5*th January*, 1886.—This firing was at the wrought-iron port plate, on which seven direct hits were obtained.

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The guns in the cupola had been dismounted and replaced by solid cast-iron cylinders about 5 feet long, strutted against the steel arcs by rounded timbers.

The general effect of these rounds will be found in Fig. 4, herewith.

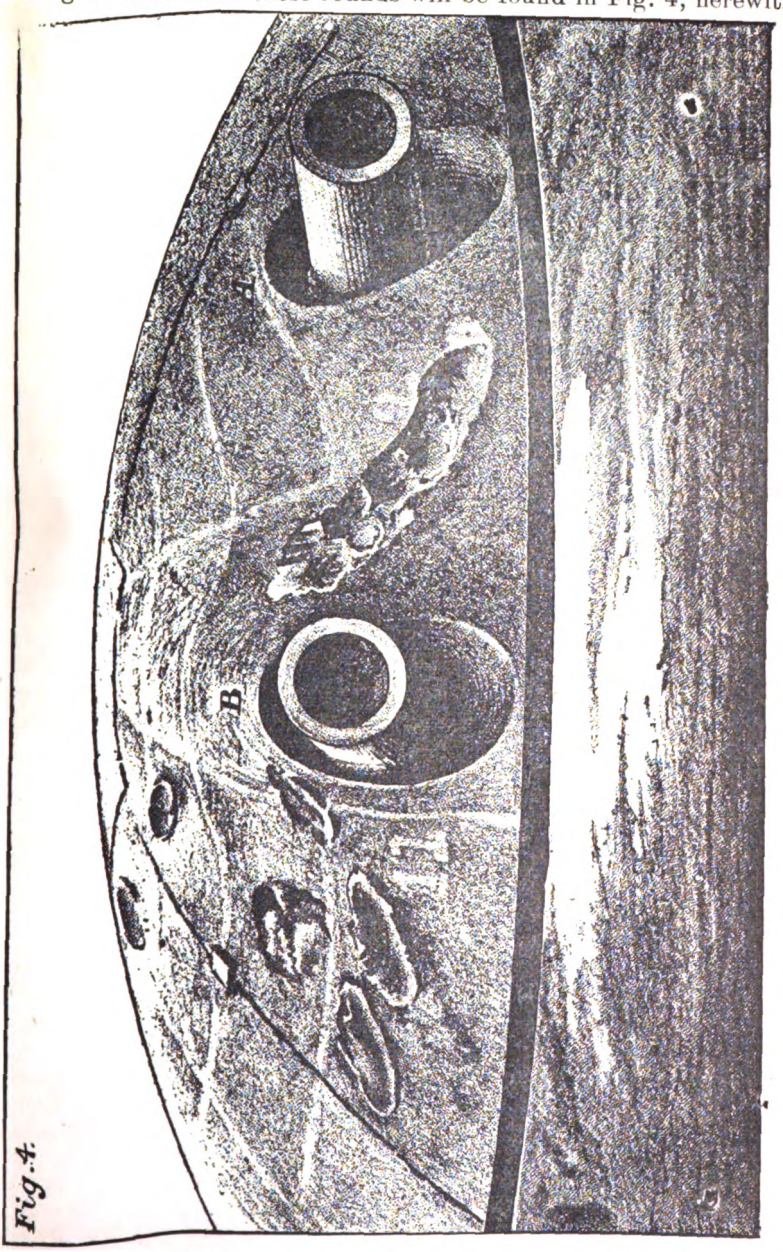

Fig. 4.

Inside the cupola, one armour bolt between the ports fell out, and two skin bolts sheared. The threads of the armour bolt, which were evidently too fine, were uninjured.

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Series (i)

8th January, 1886.—This series was intended to test the resisting power of the chilled-iron glacis plate. The 15^{cm} Krupp gun was used throughout.

The sector fired at was practically breached near the bottom. The attacking gun was mounted on a piece of built-up ground, and its axis was a little above the level of the glacis. The line of fire had an angle of depression of 1 degree 22 minutes, giving a maximum angle of impact on the curved face of about 70 degrees.

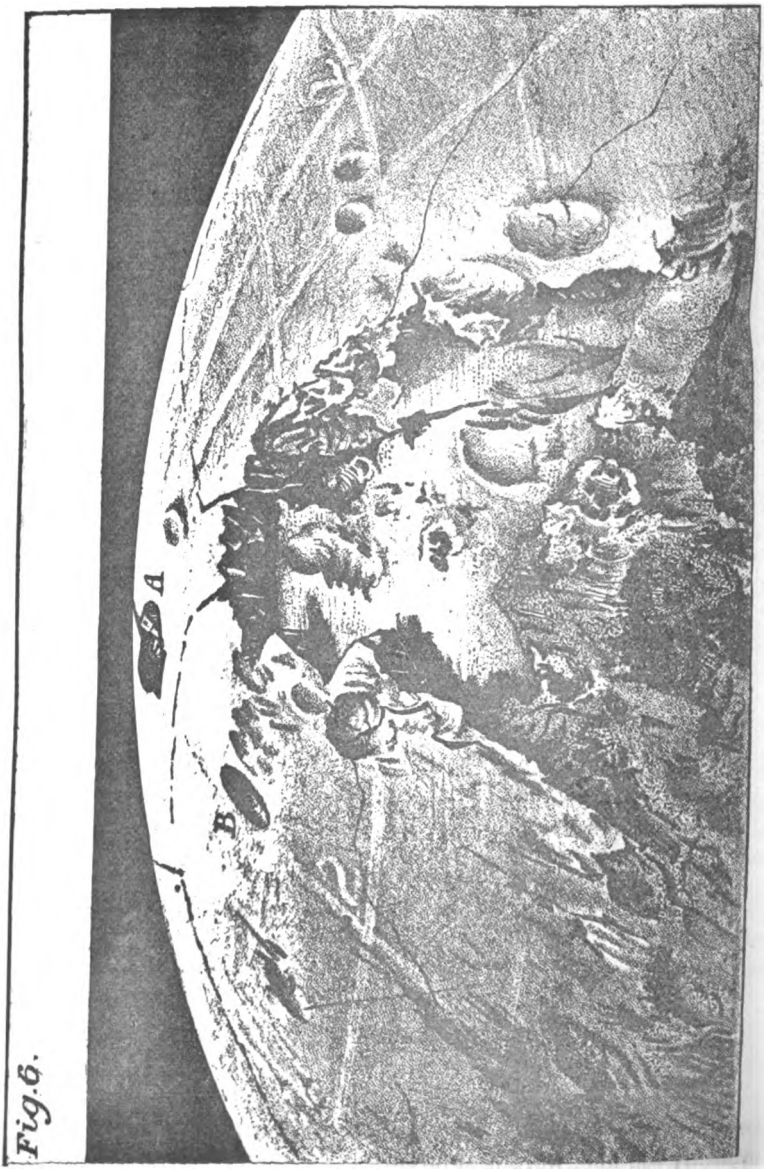

Fig. 6.

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Series (j.)

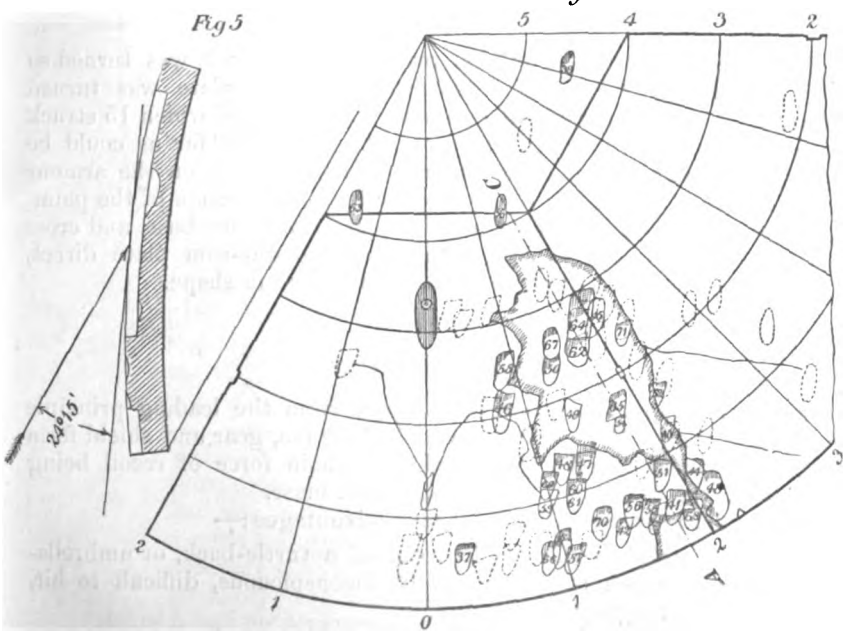
11th and 14th January, 1886.—The Committee decided to continue the practice of the 27th and 28th December, 1885, at the compound plates, until a breech was effected. The practice was extremely accurate, 35 hits being obtained, of which 7 were ricochets. The general effect may be summed up as follows:—

The steel face, which had been previously cracked in several places, began to strip at the third hit, the tendency to lamination showing itself between the two qualities of steel as well as between the mild steel and wrought-iron. The cracking and stripping proceeded gradually throughout the practice, the whole area of wrought-iron exposed at the conclusion of the series being about 5 ft. 6 ins. by 2 ft.

Fig. 6, p. 266, shows the appearance of the shield and the direction of the principal cracks developed. As a rule, the cracks did not extend to the wrought-iron; but, at the proper left top corner of the plate, a four-sided piece, area about 12 ins. square, was completely detached remaining, however, in *situ*, sustained by the skin. A single projectile striking this portion of the shield would probably have penetrated into the cupola. The total number of hits sustained by the rear centre compound plate was 31, including ricochets.—(*Vide* Figs. 4 and 5, herewith).

In the interior a considerable number of skin rivets and bolts were sheared, but appeared to have merely dropped down on the floor, and *in no* case to have flown with any force.

Fig 4



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Series (k).

17th and 20th December, 1885. This series of 30 salvoes was intended to test the working of the gear after the trials to which the cupola had been subjected in Series (*e*) and (*j*).

The shooting was evidently not greatly affected by the battering the cupola had received, but was indifferent.

The only damage the cupola sustained was the shearing of one nut in left arc of left gun; this was done by last salvo at 5 degrees depression.

Series (l).

22nd January, 1886.—This was in continuation of Series (*k*), cast-iron dummies taking the place of the guns as before. Five rounds were fired from 15^{cm} Krupp gun at the wrought-iron embrasure plate at a range of 1000 metres, with a view of obtaining a hit at the edge of the proper left port.

The damage inflicted by the first four rounds was very slight. The fifth round, had the gun been mounted, would have put it out of action; while there can be little doubt that the spar interposed between the dummy chase and the arcs saved the latter from such serious damage as would have prevented another gun from being mounted. The uninjured gun might in this case have remained serviceable. If, however, either of the cupola guns were struck fair on the muzzle, the injury transmitted to the whole of the gear might evidently suffice to disable the cupola. As it was, the only damage done, other than to dummy, was the breaking, as shown in sketch, of the small bracket supporting the right auxiliary trunnion, and this could have been readily repaired.

Series (m).

22nd January, 1886.—For this practice, the turret was turned so that the centre of the left front (wrought-iron) plate was turned towards the attacking gun. 21 rounds were fired, of which 15 struck the plate, and two the glacis plate, in line. As far as could be ascertained, the majority of these steel shells broke up on the armour plate. This no doubt was due to the shell, after deflection of the point, striking an independent blow on the plate with the base, and cross breaking. These same shells, striking a wrought-iron plate direct, either penetrated, or were thrown back unaltered in shape.

General Remarks.

This cupola cannot be considered apart from the leading principle invented by Major Schumann, in which the guns, gear and shield form part of a system rigidly connected, the whole force of recoil being absorbed in the oscillation of the compound mass.

The system possesses certain marked advantages:—

1. It lends itself to the employment of a turtle-back, or umbrella-shaped shield, which is comparatively inconspicuous, difficult to hit, and almost proof against direct fire.

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2. The guns being nearly muzzle-pivoting, not only is the size of the ports reduced to a minimum, but the exposed portion of the guns themselves becomes comparatively small. Advantage

3. By the absence of a carriage, the complicated gear entailed by the necessity of providing means of controlling the recoil at all angles of elevation is avoided. Thus much valuable space is saved, and there is plenty of room for the operation of loading, which can be performed by hand from the floor level at any position of the cupola, as well as for the storage of a large number of rounds. The traversing is also performed in the chamber in which the guns are mounted, so that the construction of a lower chamber with speaking-tube communication is rendered unnecessary. The operations of mounting and dismounting the guns are remarkably simple.

4. The method of mounting allows a range of 30° of vertical arc.

The disadvantages are :—

1. The breech of the gun has to be clamped at the required elevation for each round, and should the capstan-headed clamping screw be not properly set up, a violent blow would be dealt to the steel arcs in rear, which might distort or displace them. Disadvantages

2. The adjustment of the guns depends upon the maintenance in the same relative position of the steel arcs and of the trunnion brackets. The upper extremities of the arcs and brackets are independently attached to the inner boiler plate skin, and distortion of this skin may therefore destroy the adjustment. The skin being attached by armour bolts to the shield plates, is liable to distortion when the latter are hit. A considerable displacement of the plates took place during the trial.

Distortion of the skin may produce the following results :—

(*a.*) The parallelism of the guns may be thrown out.

(*b.*) The direction of either or both of the guns, with respect to turret sights and to the horizontal arcs, may be affected; moreover, these sights being attached to the roof plates, are liable to independent displacement from blows on the shield.

(*c.*) Any vertical displacement of the supports of the front trunnions would vitiate the elevation given on the arcs.

3. The oscillation set up by firing exercises a disturbing effect on the shooting for the following reason :—

(*a.*) Unless both guns are fired at the same instant of time, or the second when the oscillations set up by the first have subsided, it is evident that the angle of elevation of the last gun fired will be incorrect. Electric salvo firing is therefore a necessity. This fact was apparently not recognized during the experiments, and the firing throughout was by word of command, the interval between the rounds being, in many cases, well defined. The want of accuracy shown in the practice from the cupola guns was probably due in a great measure to this cause. The Kümmersdorf cupola had only one gun, and it is stated that Major von Schumann greatly prefers this arrangement.

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(*b.*) The repeated oscillation of the cupola, the blow being always delivered in the same direction, tends to give a permanent set to the volute springs supporting the rear guiding trucks. That this occurred during the experiments was evident. At the conclusion of the practice, the lower rim of the shield was visibly thrown out of the horizontal plane, and the whole mass of the cupola had acquired a permanent cant to the rear. If then, elevation was given by arc, it would be incorrect, and it would be necessary to lay the guns by quadrant.

4. The error in direction, due to movement in rotation during the interval between the rounds, is common to all two-gun turrets, but in the case of an oscillating cupola this movement becomes more complicated.

5. Indirect laying for direction is provided for by means of a pointer attached to the inner skin, and travelling over a fixed graduated arc in the inside of the pit. If this pointer is adjusted close to the arc, it is liable to be bent out of shape by striking the arc on recoil; if at a safe distance, accurate reading is rendered impossible by parallax. During the experiments the oscillations of the cupola caused the horizontal arc to be freely hammered by the pointer.

Shield. Each shield plate is attached to the inner skin by armour bolts screwed half-way into the thickness of the metal. The threads on these bolts were so fine that in some cases concussion of the shield, due to a blow, released the bolt without stripping the threads. In one instance one of the large armour bolts was sheared close to the nut and dropped into the pit. The skin to which the whole of the gear is attached being, as it were, suspended from the armour plates, and not rigidly attached to them, appears to have been capable of partially independent movement, which serves to account for the large number of bolts and rivets sheared.

The arrangement of the armour plates provided for mutual support on the principle of the arch; but, during the breaching practice, individual plates moved slightly, being lifted above the general curved surface of the cupola as well as opening out at the joint. One of the steel dove-tail wedges uniting adjoining compound plates gave way at an early period of the attack. Although this movement of the armour plates did not appear to affect their resisting power, it exerted an injurious effect on the whole system, as already pointed out.

Compound plates. The total number of hits on one compound plate was 62 direct, and 8 ricochets, which sufficed to crack it extensively, to strip the steel face off a large area, and practically to breach it. Cracks extending through the whole thickness of the face were developed at an early stage, soon after which pieces of steel began to be detached. This tendency to separation seems to indicate that the weld between the different metals was impaired by the molecular change in the material entailed by curving the plate subsequent to its construction. It is

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doubtful whether compound plates, although they lend themselves readily to high curvature, can undergo bending without loss of resisting power.

Wrought-iron plates.

The wrought-iron plate attacked received 15 direct hits which, beyond making shallow scoops, did not in the least affect its resisting power. No cracks were developed or welds opened.

Embrasure plate.

The embrasure plate received 7 direct hits, and with the exception of the round which struck the edge of the port, the plate sustained no damage. The beneficial effect of the swell round the ports was practically not tested.

FRENCH TURRET.

General Description.

Emplacement or pit.

The pit or emplacement (*see* Fig. 9, p. 272) consisted of two circular chambers, one above the other, and was built rather to suit the purposes of the experiment than to represent an actual structure. The walls were of brick throughout, with the exception of the upper portion supporting the glacis plate, which was built in cement concrete. The floor of the upper or gun chamber was at the natural ground level, and was supported on concrete vaulting, forming the roof of the lower or winch chamber, and containing the hydraulic pivot. Round the upper chamber, were arranged three recesses, 5 ft. broad by 5 ft. 10 ins. high; in one of these was a lift for delivering ammunition to the gun floor, worked by a small hand winch in the chamber below, communication between the two chambers being maintained by means of three speaking tubes. The lower chamber had the same diameter as the one above, and was provided with an independent entrance by a flight of steps from the ground level. This chamber contained the rotating gear, a set of ventilating fans, and the hand pump and gauge connected with the hydraulic pivot. The parapet was built up only on the side on which it was to be attacked.

Parapet.

In front of the glacis plate was a ring of concrete 9 ft. 6 ins. thick, measured from the exterior surface of the turret, with a depth of 3 ft., and an exterior slope of 35 degrees. The rest of the parapet was built up of sand, with a total thickness of about 30 ft.

No special arrangement had been made for magazine accommodation, and, as a rule, the ammunition for the day's practice was stored in the lower chamber.

The turret consisted of two armoured portions—

Turret.

(1.) The glacis plate set in concrete, and resting on a brick foundation.

(2.) The turret itself of the ordinary cylindrical form, similar to those introduced for ships during the American war, and since used generally in all navies.

Glacis plate.

1. The glacis is of cast-iron, and consists of four sectors of the section shown in Fig. 9, p. 272, having a total weight of 72 tons. These

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sectors merely abut against one another, and are not bolted together or attached in any way. A channel lined with asphalte, formed in the concrete below the level of the lower surface of the glacis plate (Fig. 9, herewith), is carried completely round the emplacement, and serves to drain off any rain water. An inner curb of cast-iron, in three segments and bolted to the top of the wall of the pit, forms the path for 10 slightly coned steel rollers, on which the turret revolves, and also for six others set on vertical axes, so as to prevent horizontal movement of the turret on recoil.

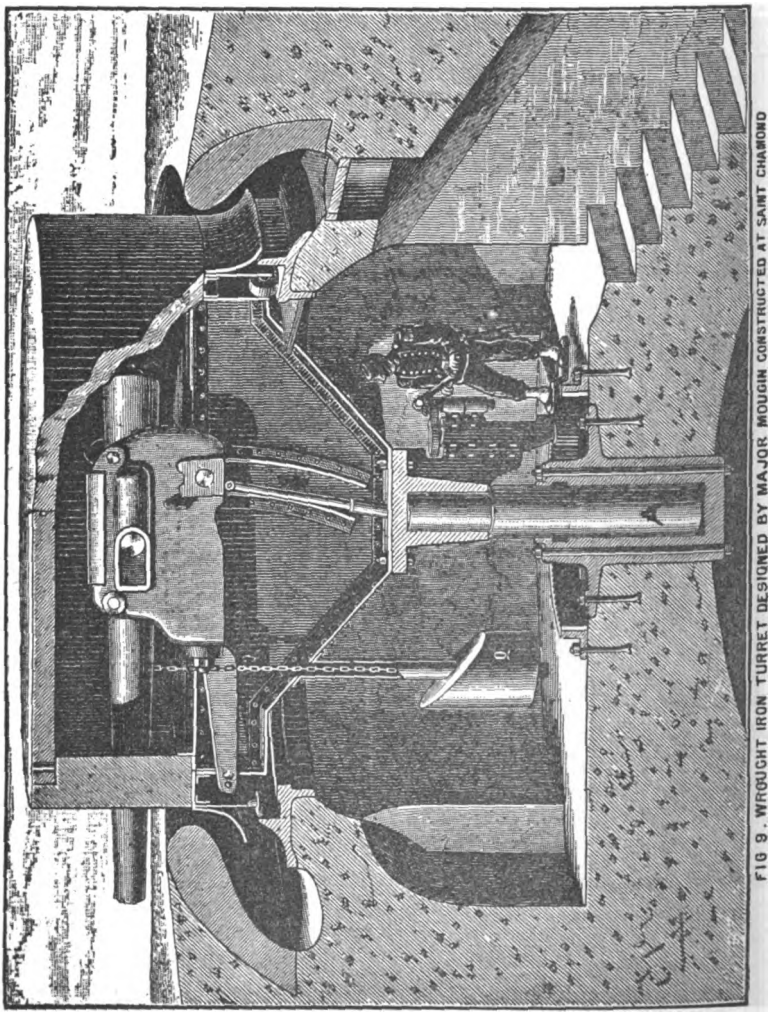

FIG 9. WROUGHT IRON TURRET DESIGNED BY MAJOR MOUGIN CONSTRUCTED AT SAINT CHAMOND

2. The curved wall of the revolving turret, exterior diameter 15 ft. 7 ins., consists of three wrought-iron plates, 18 ins. in thickness, jointed as shown in sketch (*vide* p. 273), lead being run into the joint.

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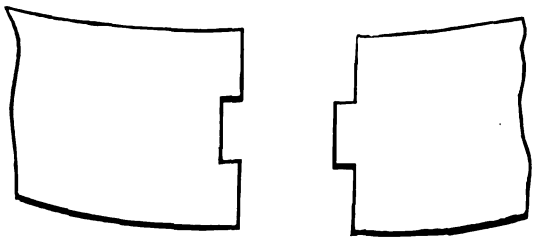
The front segment is pierced for the two guns, the ports being oval; breadth, 11½ ins.; interior height, 12·56 ins.; exterior height, 17·34 ins.; distance from centre to centre, 3 ft. 2 ins. The weight of each plate is a little over 19 tons, making the total weight of the turret, less the roof plate, about 60 tons. Proof.



The turret is closed at the top by a roof plate of wrought-iron, 7·2 ins. thick, in two semi-circular portions morticed together, and weighing altogether 19½ tons, thus bringing up the total weight of the armour of the turret to nearly 80 tons. The roof plate is rebated down on to the walls, the depth of the rebate being half the depth of the latter, and secured to them by 36 – 2½-in. screw bolts with stand-up hexagonal heads and washers.

The whole of the revolving turret, as above described, rests upon a built-up annular box-girder, in which are set the axles of both horizontal and vertical rollers.

To this substructure are attached three main brackets, forming the two compartments in which the guns were mounted. These brackets, stiffened with angle-irons, as shown in Fig. 9, p. 272, are bolted down upon a heavy casting, which rests upon the shoulder of the central pivot (A), about which the turret revolves.

This pivot is of steel, 10½ ins. in diameter, and passes down into a hydraulic cylinder of cast-iron lined with steel, containing glycerine. A hand pump placed in the lower chamber was connected with this cylinder, and, by this means, the whole moveable portion of the turret can be raised by one man, when necessary, for the purpose of so adjusting the load that little or no weight rests on the rollers. These rollers are intended to serve merely as guides, keeping the structure steady on recoil. The total weight borne on the glycerine amounts to more than 100 tons.

The turret is rotated by a pinion engaging in a large circular toothed arc encircling the main brackets at a level a little below that of the roller path. The pinion is keyed on to a vertical shaft, the upper end of which is held in bearings bracketed out from the interior wall of the pit, while the lower end passes through the floor and gears into a double purchase winch in the chamber below. The arc is built up of several pieces bolted together, and to the main brackets, and is furnished with *lignum-vitæ* teeth. The above arrangement is not shown in the plates, which represent a slightly different design. Turning gear.

In the intervals formed by the three main brackets of the turret, are the gun carriages. These consist each of two parallel brackets, to

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the front of which is bolted a T-piece (*c*, Fig. 9, p. 272, and *c*, Fig. 10, herewith) passing into the annular box-girder which carries the conical rollers, and hinged at a point below the centre of the port, this being the point about which the gun pivots. Projections on the brackets of the carriages work in curved angle-iron guides struck with radii equal to their distance from the produced axis of the front pivot hinge. Rectangular pieces of steel fitted over the trunnions of the guns, slide in slots cut in the upper portions of the carriage brackets, allowing a recoil of 18 ins.

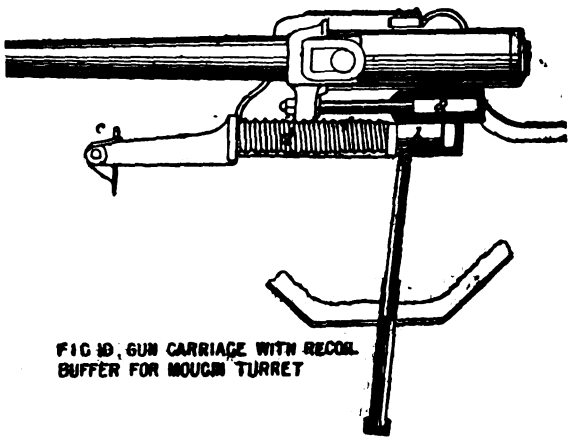

FIG 10. GUN CARRIAGE WITH RECOIL BUFFER FOR MOUGIN TURRET

levating ear.

On the top of the main brackets of the turret are two guide pulleys on either side of each gun, carrying chains one end of which is attached to the rear of the carriages, the other to a counterpoise (Q) hanging in front of the central pivot. The up and down movement of these counterpoise weights is steadied by hollow rods passing through them, and depending from the web plates (O), connecting the under surfaces of the main brackets. The weight of each of these counterpoises, 7,700 lbs., was such as to leave a preponderance of 1,100 lbs. to each gun. This preponderance is borne on the head of a small oscillating hydraulic ram (*b* Fig. 10, herewith), actuated by a hand pump attached to the main bracket in a convenient position.

ecoil rested.

Between the carriage brackets and immediately under the guns are small hydraulic cylinders (*a* Fig. 10, herewith), in which work steel pistons, their heads being attached to the gun. These cylinders are in hydraulic connection with larger cylinders, (*b*) placed immediately below them. The plunger areas of the two cylinders are as 1 : 2·8. To the ends of the plungers of the lower cylinders are attached cross heads, carrying two spindles on which are threaded "Belleville" cup springs. Both cylinders are filled with glycerine, which passes from one to the other, through a one-way valve, opening automatically during recoil, and permitting the fluid to pass into the lower cylinders, thus forcing out their plungers and compressing the "Belleville" springs. To run up, the valve is opened by hand, and the springs react, forcing the glycerine back into the upper cylinders. The initial

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load on the springs is adjusted by screws, so that they have power to run the guns out at the maximum angle of elevation of 20 degrees.

Laying. Neither guns nor turrets were fitted with sights, and there are no openings for either direct or indirect laying. Elevation is given by quadrant. Line is given in the first place by looking at the target through the gun. Round the inner surface of the cast-iron curb is fixed a gun metal ring graduated in degrees and quarters of a degree. Below this is another similar ring divided into millimetres, this last being used chiefly for giving deflection. Contact pieces, one for each gun, ride on the upper graduated arc, and can be clamped at any desired position. From the under surface of the annular box-girder depend projecting pieces, which, rotating with the turret, touch the adjustible contact pieces and complete circuits through the electric tubes by which the guns are fired. The Le Clanché firing battery is conveniently placed between the main brackets under the guns. Correction for line, after trial shots, is made by altering the position of the contact pieces on the graduated rings. To effect this, the Officer in charge has to mount a small step-ladder, and read the graduations by the light of a hand lamp.

The turret is rotated between each salvo, and the projecting pieces are hinged so as to pass over the adjustable contacts after touching them.

The inventor proposes to employ a rough method of position finding in which a "Planchette" or plane table with a squared map of the country is used. This was not tried during the experiments.

Armament. The two guns are 155^{mm} de Bange pattern, weighing nearly 3 tons; total length, 13 ft. 9 ins., with a travel of shot of about 22 calibres. Maximum charge, 9 kilos., or 19·8 lbs. Sevran-Livry powder.

	Weight. lbs.
Common (cast-iron or steel) shell	88
Steel armour piercing shell	89·8
Bursting charge of cast-iron common shell ...	3½
" " steel " ...	11½

The detachment consisted of 1 officer, 3 non-commissioned officers, and 18 men.

The operation of dismounting involves the removal of a great amount of semi-permanent gear, is lengthy and difficult, occupying at least 12 hours for each gun.

Results.

The following series (*a* to *k*) and diagrams show results of the various trials to which the French turret was subjected, arranged in chronological order.

Before commencing the regular programme, two rounds were fired from each gun, with full charges of 9 kilos. (19·8 lbs.) and "*projectiles fictives*," weighing 51 kilos. (112 lbs.), at the maximum angle—viz., 5 degrees depression and 20 degrees elevation.

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Series (*a.*)

19*th December*, 1885.—Trials for accuracy. 10 salvoes at a target 10 metres by 6 metres; range, 2,500 metres. In this series five salvoes were fired the previous day for sighting, the results of which were not published. The marking in this series was carried out as described in the case of the German cupola, and was, therefore, equally unsatisfactory.

Series (*b.*)

22*nd December*, 1885.—Trials for rapidity and accuracy. 11 trial shots, of which the last four were salvoes, were allowed before commencing this series. 25 salvoes were then fired, with the elevation and training thus obtained. Time occupied in firing 25 salvoes or 50 rounds, 1 hour 27 mins. 13 secs.

Out of the 50 rounds fired there were 44 direct hits. After the 20th salvo the target was so much damaged that the line of fire was shifted 4 metres to the left. In computing the results, these rounds have been referred to the original line. There were no missfires. The smoke hung in the turret, causing some inconvenience to the loading numbers.

Series (*c.*)

23*rd December*, 1885.—Additional trial for accuracy. 10 rounds were fired with German brown powder.

Series (*d.*)

24*th December*, 1885.—*See* remarks on the corresponding series fired from the German cupola (p. 262).

(*Series e*).

26*th and* 27*th December*, 1885.—The object of this series was to obtain 30 direct hits on the turret, at a range of 1000 metres. The turret was turned backwards and forwards through an arc of 70 degrees during the practice, with the apparent object of obtaining a distribution of the hits, such as might be expected if this system were tried under Service conditions.

The same guns were used as in the similar trial of the German cupola, and were fired singly, in pairs, and in salvoes of three, according to no apparent system. 51 rounds were fired, giving 27 direct, and three ricochet hits were obtained.

Fig. 1, p. 277, shows in development the position and appearance of the hits. The principal damage was the tearing away of a large triangular piece of metal at the top and at the junction of two plates, extending half the thickness of the wall, and laying bare the front of the roof plate. It will be seen that, owing to the movement of the turret, the hits were dispersed over an area equal to $\frac{5}{12}$ths of the whole circumference, which, no doubt, saved the plates from the severe racking they would otherwise have sustained. The maximum penetration obtained was 9¼ ins., most of the other rounds striking at angles away from the normal scooped, leaving indents of various depths. At this stage, a shell striking on the exposed junction of the

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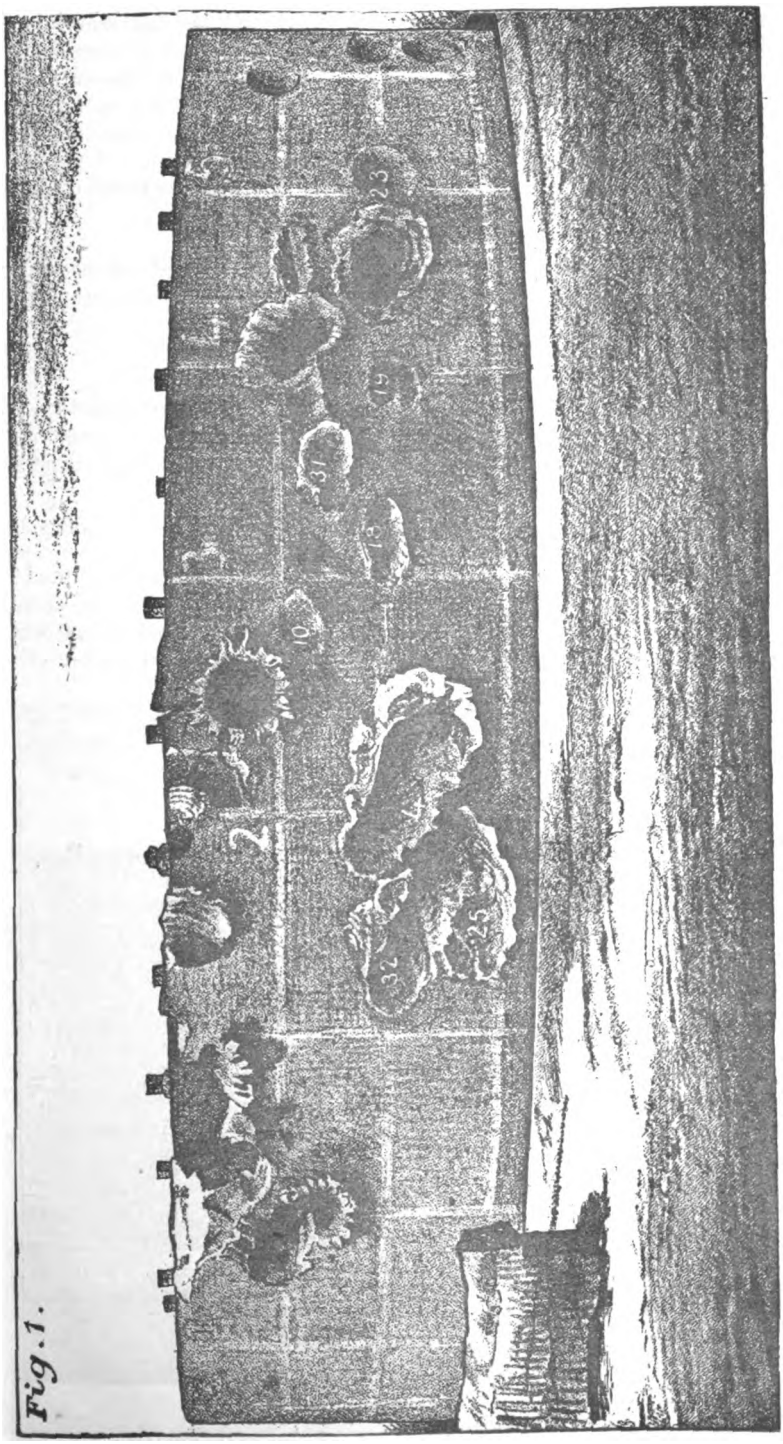

Fig. 1.

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roof plate would probably have prized it up and let daylight into the turret. This state of things was practically arrived at by three rounds. It should be remembered, however, that this was a specially weak point, since it was the junction of the two halves of the roof plate as well as that of two sectors of the wall. Only one crack was developed; this ran up to the top of the plate from the round of maximum penetration. The interior of the turret and gear were unaffected.

Series (*f.*)

27*th December*, 1885.—At the conclusion of the above series, five rounds were fired from the turret to ascertain whether the gear was in working order. The practice was indifferent.

Series (*g.*)

31*st December*, 1885, *and* 1*st January*, 1886.—Mortar practice. 70 rounds were fired, and no hits on the cupola were obtained. The shooting on the whole was fair, the maximum longitudinal dispersion being 160 metres. Three shells fell on the parapet.

Series (*h.*)

5*th January*, 1886 (Fig. 3, herewith).—The guns were dismounted and replaced by wooden dummies. The attacking guns were the same as those used for Series (*h*) in the German cupola. The object was to obtain hits near the ports, the position for each hit being prescribed

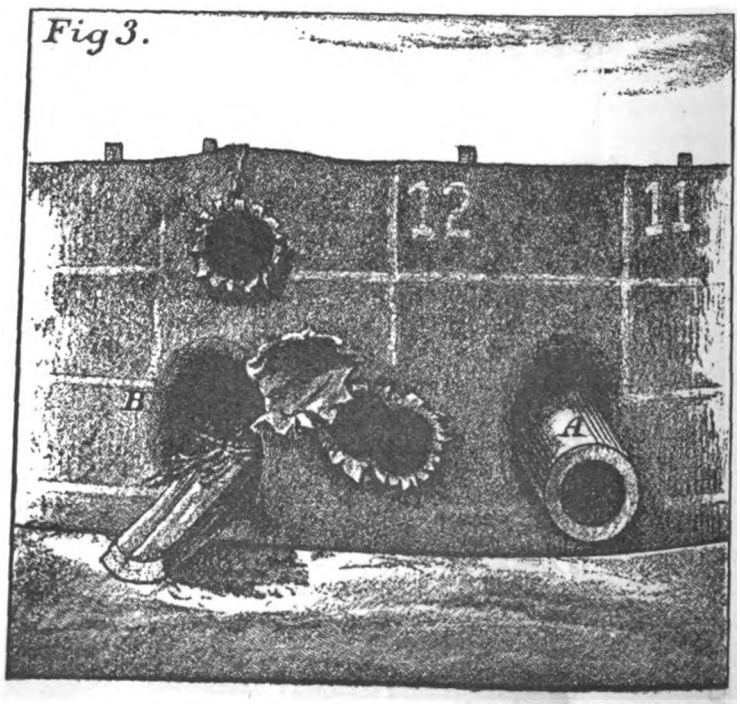

Fig 3.

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by the Committee. Of the four rounds fired, the first, striking close to the edge of the port, turned into it, and grazed the opposite cheek with its point, rebounding uninjured. This shell destroyed the dummy, and would have disabled a gun and its mounting. Nothing is to be learnt from the remaining three hits. All the shells rebounded whole. No damage was done to the gear.

Series (i).

7th January, 1886.—This series was in direct comparison with Series (*i*), German cupola, and the conditions were, therefore, apparently intended to be the same, but the attacking gun, although mounted on a built-up bank, was below the level of the glacis plate, so that all the projectiles struck at an ascending angle. In 20 rounds fired, nine direct hits and one ricochet were obtained. A number of small cracks were developed, which did not extend through the plate. This small result is attributable to the fact that, on account of the rising angle of the projectiles, and the height of the point of mean impact above the bottom of the plate, the shells striking at an average angle with the curved surface of only about 30 degrees, glanced, and did not, therefore, do their full amount of work. This explains the marked difference in these results, as compared with those obtained in the similar Series (*i*), against the German glacis plate, in which the latter was practically breached.

Series (j).

14th January, 1886.—In this series the practice of 26th and 27th Dec., Series (*e*), was continued with a view to forming a breach. The conditions of attack were the same, except that in this series the turret remained fixed instead of being rotated backwards and forwards through 70 degrees of arc. Further, only one gun was used, firing one nature of projectile—viz., Krupp steel armour-piercing shell. In Series (*e*) it was decided that meridian 0 should be regarded as the normal line, the area of maximum exposure to projectiles correct for line, and, therefore, striking normally, being 35 degrees on either side of this line. This meridian was, however, the joint of two wall plates, the upper angles of which had already been destroyed, laying bare the edge of the roof plate. The Committee, presumably on this ground, chose another meridian (No. 2) to the proper left, as the new medial line. This would seem, at first sight, to have been a concession to this turret, since the German turret, during its trial, had always presented the same meridian to the attacking gun. On the other hand, the French turret could have been practically breached by two or three well placed shots striking on the now open joint between the roof and wall plates, and it was perhaps desirable to lessen the chances of a premature conclusion to the trial.

17 rounds were fired on the 14th, and 27 on the 15th January.

Of the 44 rounds there were 32 direct hits (including one which grazed the roof plate, inflicting no damage), six ricochet hits, and six misses. The hits were distributed over an area of 5 ft. by 3 ft. 3 ins., grouping themselves mainly on the centre line, the shooting being excellent.

As a final result the turret was breached as soon as a group was

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formed near the top, but the first dangerous hit was Round 6, which struck the previously exposed junction of the roof plate, wedging it up, shearing eight bolts, and letting in daylight. The effects are shown in Figs. 2, 3, herewith, and 5 p. 281.

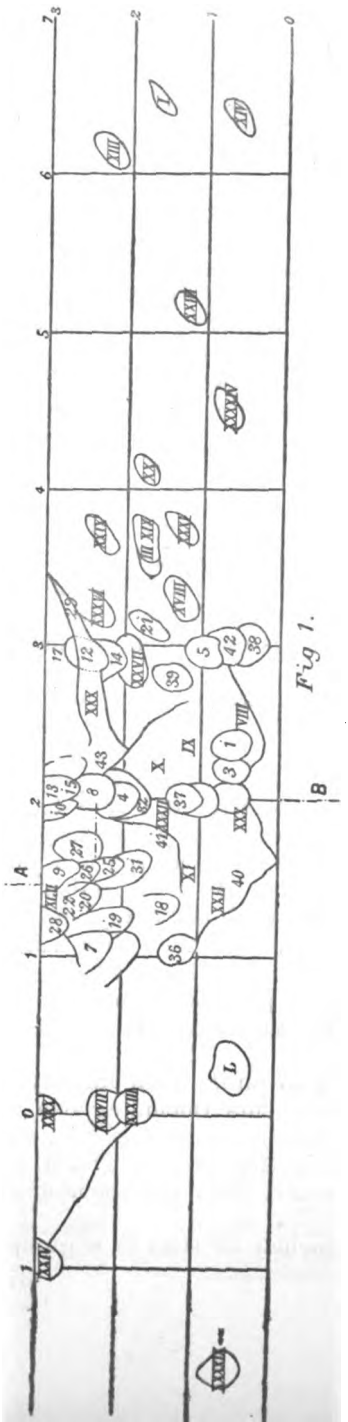

Fig 1.

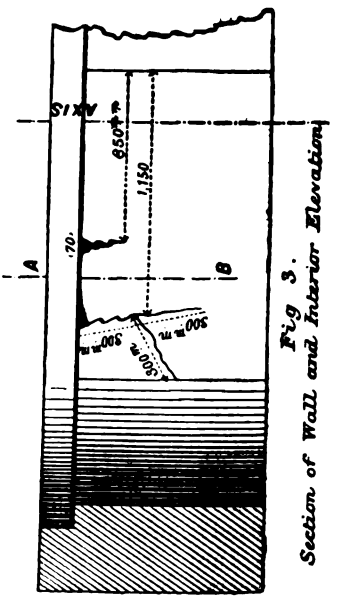

Fig 3.
Section of Wall and Interior Elevation

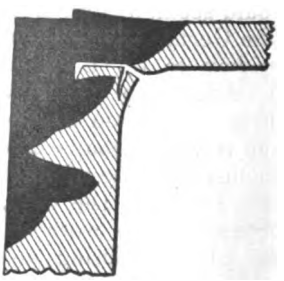

Fig 2.
Section through A.B.

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The maximum penetration obtained from a direct hit was about 8 ins.; the projectile, in such cases, being thrown back without sensible deformation. In the case of glancing shots, the damage inflicted was slight, and the shell, as far as could be ascertained, invariably broke up.

An examination of the turret, at the conclusion of the series revealed no damage to interior or gear, the rotation being unimpaired.

Fig 5.

Series (*k.*)

20*th January*, 1886.—20 salvoes were fired in this series to test the working of the turret after the breaching trial.

The mean time per salvo in this series was 3 mins. 48·8 secs., as compared with 3 mins. 38 secs. in Series (*b*).

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General Remarks.

The French turret presents the following novel features:—

1. The floating pivot.
2. The complete closing of all apertures, with the exception of the ports.
3. The absence of any inner skin, and the supporting of the side-plates by means of the roof and the base ring only.
4. The system of automatic electric firing, necessitated by (2).
5. The employment of Belleville springs to "run up" the guns after firing.

1. The floating pivot unquestionably added largely to the facility of traversing. The total load, of about 100 tons, could not have been otherwise moved without great labour. Whether and to what extent "creeping down" took place cannot be stated. The turret was throughout in the hands of the artisans specially brought from the St. Chamond Works, and they were, consequently, enabled to adjust the incidence of the load upon the trucks to any extent that might have been required.

2. The avoidance of all apertures, by which a chance splinter might enter, has been claimed as a considerable advantage for the French turret. In theory it may be desirable to avoid remote contingencies; but certain risks have to be accepted in war, and, in obviating them, practical disadvantages may be incurred. Notwithstanding that the gun chamber of the French turret had a large door always open, the accumulation of smoke was, at times, excessive. Had this door been closed, or in communication merely with a passage, it is doubtful if long continued firing would have been possible. Moreover, but for this door, the whole of the work inside the turret must have been carried on by the light of lanterns, which, considering the general inconvenience of the arrangements, would have been no easy matter. Finally, the impossibility of direct observations from the turret itself constitutes a definite disadvantage to the system. However desirable it may be, as a general rule, to regulate fire from a distant and secure observing station, it appears altogether unwise to abandon the possibility of obtaining a direct aim under the many circumstances which may arise. The theoretical invulnerability of the gun detachment may thus be too dearly purchased.

3. The absence of an interior skin was advantageous, inasmuch as there were no rivet or bolt heads to fly when the turret was struck. On the other hand, a large number of the bolts, attaching the roof to the walls, were sheared by a single hit, and a shell, striking below the exposed edge of the roof-plate, would, undoubtedly, have raised it, thus seriously affecting the stability of the whole structure.

4. It cannot be said that the principle of automatic firing was ever properly tested. There appears to be a considerable risk in thus trusting to an electric contact being completed at a precise instant.

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Unless the contact pieces were always chemically clean, an uncertain delay might occur which could not be corrected for. The mere wearing of the rubbing surfaces would also be a source of inaccuracy, but would, of course, be less a matter of chance. Theoretically, provided that the pointers and arcs were correctly adjusted, the firing of the two guns should have been absolutely simultaneous, which was not always the case. Possibly, on account of the reasons above indicated, the earlier practice, Series (*a*), (*b*), and (*f*), was decidedly indifferent. In Series (*k*) better shooting was obtained, possibly because some alteration of the contact pieces had been effected. It is worthy of notice that, of the 21 salvoes in this last series, nine were fired by friction tubes, thus involving merely an optical adjustment of a pointer on the fixed horizontal arc.

5. The action of the springs in forcing the guns back into the loading position appeared to be satisfactory; but it is impossible to state whether the recoil presses necessitated special care or attention during the trials.

General Conclusions.

The value of these important and costly experiments was sensibly modified by certain of the conditions under which they were carried out.

1. The power of the guns employed in the attack fell far short of the standard of a modern heavy siege train. The Krupp 15^{cm}, and the de Bange 155^{mm}, practically 6-in. guns, fired a maximum charge of 19·8 lbs., with projectiles varying in weight from 69·3 lbs. to 90 lbs. The muzzle velocity with the armour-piercing projectiles being only about 1500 ft.-secs. As a comparison, it may be stated the 6-in. B.L. gun proposed for our heavy siege trains, fires an armour-piercing shell weighing 100 lbs., with a charge of 34 lbs. of powder, giving a muzzle velocity of 1830 ft.-secs. Thus, even discarding the probability of the employment in future sieges of jointed guns of increased power, existing armaments are far superior to the ordnance selected for these trials. Conditions of trial.

It is to be remembered that if cupolas are ever largely employed for the defence, every effort will be made to bring the heaviest siege artillery against them. It is in all respects, therefore, to be regretted that the most powerful weapons available were not employed for the attack.

2. Guns identical with those above described were mounted in the turrets. If such costly structures are to be employed at all, it is clear that the best possible guns must be mounted in them, since there is an obvious anomaly involved in expending £10,000 in mounting two weak siege guns. Even supposing that the calibre of the guns so mounted were limited to 6 ins., they would not be less powerful than our Mark IV., giving a muzzle velocity of 2050 ft.-secs., with a charge of 55 lb. brown powder and a 100 lb. shell. Whether it would be

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possible to mount such a gun in either of the turrets experimented with cannot be said to be established. In the case of the German cupola it is clear that radical structural alterations might thus be entailed, since the retention of the non-recoil principle might involve a prohibitory increase of weight, strength, and cost.

With the French turret similar difficulties present themselves, though, perhaps, in a less degree.

3. A combination of a service and a manufacturers' trial, which was practically the system adopted, is in all respects unsatisfactory. The shooting was carried out under Roumanian Officers with Artillery detachments; but the artisans of the competing firms were at hand to assist in any way that might be required, and throughout the trials the turrets appeared to be in charge of their exhibitors, whose skilled workmen, living on the spot, were able to repair damage, effect adjustments, and generally make good any defects which arose during the practice. Throughout the trials the respective inventors were not only permitted to give directions and suggestions of all kinds, but to express their mutual opinions with regard to their rival's turret with perfect freedom.

4. The method of recording the results of the shooting from the turrets for accuracy left much to be desired. The telephoned reports were based on observations by an Officer, who, not having time to measure individual hits or grazes, judged them as best he could from his shelter. It was specially desirable to test the accuracy of adjustment of the guns; to ascertain if their parallelism was effected; to gauge the disturbance of one gun caused by the discharge of the other; and, in the case of the French turret, to form an estimate of the practical efficiency of the system of automatic firing. For all the above named purposes the recording of individual shots was essential, this condition cannot be said to have been complied with.

The time of year in which the experiments were carried out, and the prevalence of fog, snow and extreme cold, doubtless added much to the difficulty of the conduct of the trials.

5. In the breaching trials, the system of firing salvoes of two or three guns indiscriminately, rendered it impossible to identify the effect produced by shells of a particular class. Moreover, speaking generally, there was no opportunity for ascertaining whether particular shells broke up, or the effect on the shells themselves of impact under varying conditions. Again, little or no time was allowed for adequately recording the effect on armour plates of successive rounds. On one occasion as many as 56 such rounds were fired on a single day. Thus, the recorded results cannot be regarded as sufficiently detailed, while the trials fail to provide such data with regard to the behaviour of steel projectiles as might have been obtained.

It is now proposed to compare the merits and performances of the two turrets under separate heads.

1. Emplacement.

In this respect the German cupola has a marked advantage. In

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the case of the French turret, the lower chamber necessitates either a considerable excavation or a high command with its attendant disadvantages of increased visibility. The absence of any sort of recoil carriage in the German cupola leaves the gun chamber comparatively free. Thus the whole of the operations of loading, training, &c., are carried out on one floor, and therefore under the eye of one responsible officer, while the recesses provide space for the storage of a considerable quantity of ammunition. Moreover, this one chamber is, by day, well lighted from the back passage and the man-hole at the top, while the lower story of the French turret is dependent always on artificial light and ventilation.

2. Mountings.

Both systems of mounting worked well, and did not appear to be affected by the trials. The German system is open to the obvious objection that its applicability to a high velocity gun is still unproved, while there are evident difficulties to be met. The continued recoil, even of these weak guns, was sufficient to give a permanent set to the springs supporting the rear trucks. The effect of this would be to cause an error in elevation as given by arc, and practically to necessitate recourse to the clinometer. In any case, the suspending of the guns from the inner skin of the shield is open to objection. Further, the vertical steel arcs, against which the breeches of the guns rest, are supported above by the inner skin, and below by the built-up base resting on the pivot, an arrangement capable of leading to disturbance of the position of the arcs themselves relative to each other, and to the axes of the trunnions.

The employment of Belleville springs, as in the French turret, to run out the guns, would probably be applicable to more powerful guns.

The system of mounting adopted in the German turret, possessed, however, the incidental advantage that the size of the ports was reduced to a minimum, while the exposed portion of the chase of the guns was less than half that entailed by the design of the French turret.

3. Facility of Mounting and Dismounting Armament.

In the design of the German cupola the desirability for providing easy and simple means for mounting or replacing the guns has been recognized, and the arrangements have been extremely well thought out. The whole operation is quite straight forward, and can be performed by ordinary gunners. There is no doubt, that, with a certain amount of drill and practice, the time quoted might be reduced at least one half. On the other hand, in the case of the French turret, the mass of ironwork and gear which has to be removed in the process of dismounting renders the assistance of skilled artificers an absolute necessity. It was impossible to ascertain the exact number of hours expended in removing the guns from this turret, as the work was probably continued night and day, but on each occasion the operation appeared to extend over two days.

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4. Ventilation and Lighting.

The ventilation of the German cupola was far superior to that of the French turret. This was mainly due to the manhole at the top of the former, by which a direct draught was promoted. In the French turret, after firing, the smoke accumulated in the upper portion of the turret to an inconvenient extent. If the gun-chamber had not opened directly into the air, this drawback would have much increased. The lower chamber of the turret was provided with a fan, apparently intended to assist ventilation; but this arrangement, if it was used, does not seem to have been successful. It is to be observed that ventilation of the lower chamber also would have to be secured if the design were applied to a work of defence.

The French turret entailed artificial lighting at all times, while the man-hole in the roof-plate of the German cupola provided ample illumination for day firing.

5. Loading.

The large space available in the German cupola, and the fact that all the operations of loading were performed from the floor of the gun-chamber, was an undoubted advantage.

In the French turret, not only had the ammunition to be sent up by a lift from the gun floor to the platform above, but the whole arrangement was extremely cramped and inconvenient. While, in the one case, any gunners would in a short time have been able to carry out the loading operations with the necessary rapidity; in the other, careful special training would be necessary. On the other hand, it is to be observed that the German system of mounting practically limits the choice of breech action to a side wedge of the Krupp type, and precludes the employment of a breech-screw.

6. Elevation.

The guns in both cupola and turret being counterpoised, elevation was given without difficulty. In the German cupola, the guns being overbalanced, the breeches were hauled down to elevate. In the French turret, there was a small preponderance, and the breeches were raised by a little ram, actuated by a pump. It would be interesting to know whether this ram was able to maintain the breech at a constant elevation, or whether any slight variation took place. No experiments were made with a view of testing this point. In the German cupola, the breeches were clamped as soon as the required elevation had been obtained.

7. Traversing.

The French turret appeared to traverse more easily and smoothly than the German cupola, in spite of its far greater weight. The former being intended always to make a complete revolution between each salvo, the designers had been led to adopt the floating pivot, to which the comparative ease of traversing was mainly due. The greater finish of manufacture of the French turret was not without influence

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however; while the adoption of wooden teeth in the main gearing was doubtless advantageous. These features are of course equally applicable to the German cupola. The latter possessed the advantage that the traversing, being carried on in the gun chamber, could be directed by the officers in charge by signal, without the necessity for having recourse to a speaking tube.

The horizontal arc of the German cupola could be read without difficulty from the floor of the gun chamber. In the French turret it was necessary to mount steps and to use a hand lantern. On the other hand, the arrangement of the pointer in the former case was decidedly objectionable; since, although placed at a distance so great as to involve parallax, it nevertheless struck the arc violently during the oscillations of the cupola on recoil.

8. Sighting.

The power of laying by sight appears to be a decided advantage in favour of the German cupola. Not only can direct laying be employed which, in the case of a moving object, would be of the highest importance, but back laying by means of the hole in the rear armour plate can be utilized.

In the French turret, unless a system of position finding is applied, it is necessary in the first instance to lay the guns through the bore by means of a sighting tube or cylinder. Thus, if comparative trials at a moving target had been carried out, or even practice against dispersed targets, the German cupola might have been expected to show a marked superiority. It is to be observed, also, that this cupola lends itself equally well to the employment of a position-finding system.

The complete closing in of the French cupola, and its absolute dependence under all circumstances on information supplied from without, is a condition which is likely to recommend itself only to the pure theorist. The chance of a shrapnel ball or machine gun bullet finding its way into the turret through the opening in a conning tower may well be accepted, in consideration of the advantage of allowing the Commanding Officer of the turret an occasional view of the distant terrain, instead of rendering him completely dependent on an observer who may be killed, or a system of communication which may break down. Such a break down would probably result in the continuation of a useless fire, and a waste of ammunition.

9. Accuracy of Fire.

It is greatly to be regretted that no series were fired with the object of obtaining comparative range and accuracy groups. The results of each round, or salvo, were usually telephoned back to the firing point, and as these results could not in many cases be other than approximate, the practice does not afford a satisfactory comparative test of the shooting capacity of the cupola and turret. Again, for the reasons stated on p. 269, the principle adopted in the German cupola appears to demand electric salvo firing as a condition of satisfactory practice, and the fact that the salvoes were all fired by word of command, resulting in many cases in a distinct interval

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between the rounds, doubtless told against the accuracy of the fire from the cupola, while precluding the formation of a just estimate of its capabilities. Generally speaking, the shooting was indifferent, which must be partly attributed to the conditions of the mounting, and also to the changes in direction and elevation being made on information sufficiently accurate. On the other hand, the practice in Series (*k*) from the French turret, during which it is believed that no results were telephoned, and no corrections in elevation or direction were made, was decidedly better. In neither cases is there any reason to suppose that the shooting was affected by the battering the cupola and turret received in Series (*e*) and (*j*).

In the case of the French turret, the gun mounting being entirely independent of the shield, there appears to be no reason to expect any inaccuracy from this cause. In the German cupola, however, it is evident that errors might arise from a distortion of the skin, produced by movement of the supported armour plates.

The efficiency of the automatic system of firing, which forms one of the special features of the turret, cannot be said to have been properly tested. Judged by Series (*k*), it appears to have acted fairly; but more extended trials would evidently be necessary to dispose of the objections pointed out. On the other hand, the arrangements for laying the German cupola for direction by arc and pointer were rough and unsatisfactory.

10. Rate of Fire.

A comparison of the two Series (*b*) shows that the German cupola fired 25 salvoes in 2 hrs. 27 mins. 20 secs., giving a mean time per salvo of 5 mins. 54 secs.; while the French turret required only 1 hr. 27 mins. 13 secs., or an average of 3 mins. 38 secs.

This comparison is, however, scarcely just to the German cupola, which was made to perform a whole revolution after every salvo, merely because the French turret had been specially designed for this purpose, and could be loaded during rotation. This was claimed as an advantage by the inventors, since the guns were thus rendered invisible, and practically invulnerable to the attack during a portion of the period of rotation. It may well be questioned whether this advantage has any real existence. When facing the attacking battery the guns present a small mark; when nearly at right angles to the line of the enemy's fire they offer a broadside target, which on account of the protrusion of the French guns is considerable. Under service conditions, the fire of the attack from the first artillery position at least, would not be so extremely accurate that each round would strike close to the ports, if the turret were not rotated. Hence it is doubtful whether the chances of a hit on the muzzle or chase are not rather enhanced by turning them round and presenting a broadside view twice after each salvo. In any case, the rate of fire is much reduced by the operation, while a great strain is thrown on the traversing numbers, who would have to be relieved at short intervals.

In Series (*k*), fired after the breaching trials, the average time per

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salvo in the German cupola was 6 mins. 35·8 secs., while in the French turret it was 3 mins. 48·38 secs. Thus the increase in the averages was 41·8 secs. and 10·38 secs., respectively.

No opportunity was afforded to the German cupola of proving its rate of fire without turning; but in Series (*b*) the mean time per salvo for loading and laying was 1 min. 29 secs., which must approximately represent the maximum. It is evident that similar guns on siege mountings are capable of a greater speed of fire, and the loss of time is due to the inconvenience of performing the loading operations in the cupola, and also to the greater weight to be traversed.

The two Series (*d*), apparently intended to test the performances of the cupola and turret against a moving target, obviously afford no data, comparative or otherwise, which can be regarded as of value.

11. Resistance of Shields.

The German cupola received in all 85 direct and 12 ricochet hits. As will be seen from Figs. 4, 5 and 6, pp. 266 and 267, by far the greater proportion fell upon a single compound plate, and were grouped near its proper left edge. The general result was the stripping off of the steel face over an area of about 10 square feet. No actual breach was effected, but the left hand top corner of the plate attacked was detached and remained merely supported in position on the inner skin; a single shell falling on this part of the shield would have penetrated. When it is remembered that this one plate received 51 hits, including ricochets, the resisting power must be classed as high. This excellent result is evidently due to the flat curvature of the design, and not to the material. It was shown that the steel face was first cracked up, and eventually detached under successive blows, proving that the weld between the two metals was imperfect. This was probably due to the re-heating and bending of the plates after manufacture. The wrought-iron plate was unfortunately not subjected to a comparative test, as it only received 15 hits, well distributed. This plate, however, exhibited no signs of cracking, and individual hits merely made scoops in the metal varying from 0·4 in. to 1·12 in. in depth, the shells in most cases breaking up. There seems to be no doubt that a curved wrought-iron plate, even of this small thickness (8 ins.), is capable of successfully resisting a large number of hits, since it would appear extremely difficult to obtain any cumulative effect. It was intended to fire a series of flat-headed projectiles against the curved shield, as it was considered that better results would thus be obtained. There is obviously no reason to expect that this would be the case, since experiments at Shoeburyness have proved conclusively the superiority of ogival shot under all circumstances.

The armour of the French turret received altogether 63 direct and 9 ricochet hits, of which the greater number were grouped over an area of 21 square feet. Projectiles striking normally, penetrated to a maximum depth of about 9 ins., the steel armour-piercing shells usually rebounding uninjured. When any hit took effect within about 18 ins. of the edge of the plate, cracks were generally developed extending to that edge. The tendency to form vertical cracks was

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specially noticeable. This weakness was probably due to the initial strain induced on the outer surface by bending the plate. An examination of the fracture showed a large crystallization towards the face of the plate. In the case of oblique impact, the projectiles generally broke up, forming irregular cuts. In some instances, however, a sidelong print of the projectile was formed in the soft metal. The turning of the turret during the breaching practice in Series (*e*) rendered it impossible to estimate the angle of impact of individual rounds. The principal damage was caused by a number of shells striking near the top of the wall, laying bare the junction with the roof plate, and finally prizing up the latter and shearing a large number of the attaching bolts. At the conclusion of the breaching practice, therefore, a projectile striking the exposed lower edge of the roof plate would probably have lifted it bodily, while a portion of plate near the top of the wall was so weakened that it could easily have been penetrated.

It will be seen, therefore, that these results bring out the great advantage of the spherical model. Although a direct comparison is hardly possible, there is every reason to suppose that the 8-in. wrought-iron plates of the German cupola possessed a power of resistance fully equal to that of 18-in. wall of the French turret.

If a more powerful gun had been employed in the attack, the French turret would have suffered in a relatively higher degree.

12. Damage to Interior.

The number of rivets and small bolts detached during the attack on the German cupola was considerable. Although they appeared to have merely fallen without force, it is evident that this liability must be guarded against in a fighting machine. The threads of the large armour bolts were so fine that one of them was actually shaken out of the shield, apparently uninjured. This ought not to have been possible.

The employment of a rope mantlet, or of an independent inner skin, would prevent the fall of rivets, &c. It would probably be possible, however, to cushion the shock transmitted from the armour plates to the skin, so as to obviate this great disadvantage.

The breaking of a pinion belonging to the traversing gear, appears of less importance. It is clear that this pinion should never have been made of cast-iron.

The absence of an interior skin in the French turret proved a great advantage. There were no bolts or rivets which could, under any circumstances, have fallen, and the damage was nil.

13. Glacis Plate.

The glacis plate trials, Series (*i*), do not lend themselves to a satisfactory comparison. On account of the considerably greater height of the French turret, with respect to the attacking gun, its glacis ring could not be hit at so great an angle as that of the cupola. The flatter curvature of the French section told further in

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its favour. Six direct hits were obtained on the German glacis plate, forming a group near the bottom edge, and breaking off a large fragment, which, however, was not detached. The French glacis plate received nine hits, forming a dispersed group about half-way up. Thus all the hits were very oblique, and, though numerous hair cracks were developed, no real damage was effected.

The attack was carried out at 54·6 yards range, and in the case of the German cupola 16 rounds were fired before the glacis plate could be reached, although the spade was freely used meanwhile in clearing away the sand and concrete débris. It is sufficiently evident that, even at 1,000 yards, it would be perfectly useless to attack either glacis with such guns as were employed in these experiments. It appears doubtful, indeed, whether a cast-iron glacis ring of this form could be successfully attacked by any gun or howitzer which could be put into the trenches.

14. Visibility.

The German cupola possessed a marked superiority in the smaller and less conspicuous target offered to the attack. The result of this was that in Series (*e*), 85 rounds were fired at the cupola in order to obtain 30 direct hits; while in the case of the turret 27 hits were obtained in 50 rounds. Taking Series (*e*) and (*j*) together the comparison is 58 hits in 137 rounds, against 59 hits in 94 rounds. In other words, at a range of 1,093 yards it required about one and a half times the number of rounds to obtain the same number of hits on the cupola as on the turret.

The low, flat, umbrella-shaped cupola could, if properly coloured and with a suitable back ground, be rendered almost invisible.

15. Embrasures.

The attack on the embrasure plates affords no comparative data. Twelve rounds were fired against the German cupola, and only four against the French turret. As soon as a hit was obtained on the edge of the port, the gun in each case must be considered to have been destroyed.

In the case of the German cupola, however, the steel casting, supporting the right front trunnion was also broken, but could have been replaced without difficulty. To this damage the French turret was not liable; but, on the other hand, the main danger arising from a hit at the port is evidently the destruction of the gun.

General Remarks.

From what has been said above, it will be evident that both the structures under experiment fall far short of the ideal land service cupola. The practical value of the trials was greatly reduced by the weakness of the guns employed. If turrets of any form are to be adopted in the main armament of land works, it is clear that much heavier guns must be put into them. The great expense involved

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could not otherwise be justified. The cost of the French turret alone was about £10,000, exclusive of its armament, and for this sum about six overbank guns of greater power could be provided. It may fairly be questioned whether the latter would not be a wiser mode of expending such an amount.

Again, if cupolas of any form come into general use, the heaviest possible siege guns will be brought against them. The Russians already have a screw gun of 8-in. calibre, and the development of this system promises to confer increased power on the attack, which is limited only by the weight of the heaviest portion. In any case, the Krupp and de Bange guns employed at Bucharest do not even reach the standard of existing siege ordnance. For these reasons, any deductions which can be made from the trials in question are necessarily subject to qualification.

Summing up; the main advantage of the German cupola was its form, and the main defect the detachment of the interior bolts and rivets. In the case of the French turret, the principal merits were the floating pivot and the absence of an inner skin; while the chief drawbacks were the want of any means of direct laying, the bad ventilation, the complication and general inconvenience of the interior, and the greater cost of the emplacement.

By combining the best features of the two designs it is possible that a satisfactory military machine could be arrived at. A cupola with a wrought-iron umbrella-shaped shield, supported on a floating pivot, and armed with guns provided with a recoil mounting and port pivoting might meet all requirements. The turtle-backed shield is the practical recognition of an important principle, and constitutes a decided step in advance. One of the most important facts brought out at Bucharest was the great resistance of a comparatively thin wrought-iron plate of this flat curvature. It is significant that the designer of the French turret has since proposed a structure in which the German model is copied bodily as to form.

The general question of the necessity for the adoption of cupolas for land defence receives no new light from the Bucharest trials. The armour in both cases received a number of blows, probably representing a siege of many months duration. But, on the other hand, it is evident that had the guns been turned towards the attack they would have been many times disabled. Against the direct frontal fire of high-velocity guns, the cupola appears to afford no increase of protection commensurate with its cost. Against curved fire and flank fire, however, the gain of security is considerable.

If a horizontal shield, capable of providing protection against the projectiles of the heaviest siege howitzers, can be provided for the pits of disappearing guns, this system would seem to be preferable to any land service cupola at present devised. The main point of weakness, the opening through which the gun is raised and lowered, is perhaps more than counterbalanced by the absence of a well-defined and always visible target.

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PICRIC POWDER

FOR

GUNS AND MAGAZINE RIFLES.

Taken partly from "Russian Invalid," of 3rd February, 1887.

BY

CAPTAIN W. H. H. WATERS, R.A.

Of the five great Continental Powers, Russia is the only one which has not adopted a pattern of magazine rifle for her infantry, but nevertheless the question has excited, and is still exciting, a great deal of attention in that country. The *Invalid* is of opinion that repeaters will only form a new era in small-arm armaments where their introduction is accompanied by that of a new and better powder, and this belief is shared by many foreign artillerists, especially in France. As far back as 20 or 25 years ago, various new kinds of powder were proposed to be introduced both for guns and rifles, but until quite recently no country adopted any of the different inventions which have made their appearance from time to time.

Pyroxyle powders have been much used latterly by sportsmen, and, besides these, the French have experimented largely with picric powder of green colour, made of ammonium picrate and saltpetre, and invented by Colonel Brugère. In 1876, experiments were carried out at Greenoble in France, with a Chassepôt rifle, and it appeared that a charge of 2·6 grammes of Brugère's powder gave as great a velocity as did 5·5 grammes of the ordinary French service powder. The former also acted very uniformly, the fouling of the bore was much less, the amount of smoke much diminished, and the barrel did not deteriorate. From 1876 to 1880, the matter was allowed to rest, but in this latter year the French Minister of War appointed a Committee on Explosives to investigate the question fully. At the same time the question of magazine rifles was the subject of increased attention abroad, and it was found that the adoption of these weapons would necessitate, sooner or later, that of a new form of powder. The Committee went into the whole question thoroughly, not only as regarded rifles, but guns also, and the results of the trials carried out in 1881, demonstrated that, under the usual conditions of loading, the Gras rifle of 1874, and

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guns of 90 millimètres and 155 millimètres gave considerably better ballistic results when ammonium picrate powder was used, than was the case when the ordinary service powder was employed. The experiments were continued on a large scale with new cartridges, and it was proved conclusively that, with the Brugère picric powder, great accuracy, and the requisite velocities, are attained with bullets weighing 25 grammes and charges of 2·8 instead of 5·25 grammes, the latter being the charge with ordinary powder; also the pressures in the barrel were less with the new than with the old powder.

The same satisfactory results showed themselves where the 90 and 155 millimètre guns were fired, and the trials with these weapons were continued, with a view to finding a powder more slow-burning than those already tried, thereby allowing larger charges, better adapted to the existing chambers of these guns, to be used.

Magazine rifles of various patterns and of different calibres, were also fired with the new powder, and the result has been that the French have decided on adopting a magazine rifle of 8 millimètres calibre with which Brugère's picric powder, mark V., is to be employed.

Of course, we all know that Germany took the lead in introducing repeaters, her present pattern of rifle having been decided upon in 1884, but the French delayed following her example, until a better weapon of reduced calibre could be produced. Such a weapon would require a new type of powder, and both articles are now being rapidly manufactured in France. Great secrecy, however, has been observed by both Governments, so that it is difficult to get hold of any substantial facts. Nevertheless, we know that experiments have been carried out in Germany with pyroxyle and Schultze's powders from the service rifle of 11 millimètres calibre, and there is no doubt but that this question is not neglected by German artillerists, the less so as pyroxyle powder is manufactured in the country, and is much used by sportsmen there.

The new French cartridge, it appears, weighs 28 per cent. less than the old one for the Gras rifle, and if men can really only be induced to carry a maximum of 70 cartridges, they will now be able to carry 100 without any increase of weight. The question of the adoption of new rifles and cartridges in France might possibly exert some influence on the political relations which may exist between the two great Powers to whom allusion has been made. Germany has already over 300,000 repeaters in use, her manufactories can turn out about 30,000 a month, and she is considering the question of a new powder; in a very short time France will also be able to turn out 30,000 of the new rifles in the same time, but at present she has large supplies of small arms of all kinds of patterns. If, then, the relations between the two countries are at all strained, might not Germany naturally endeavour to decide the struggle before her rivals are re-armed?

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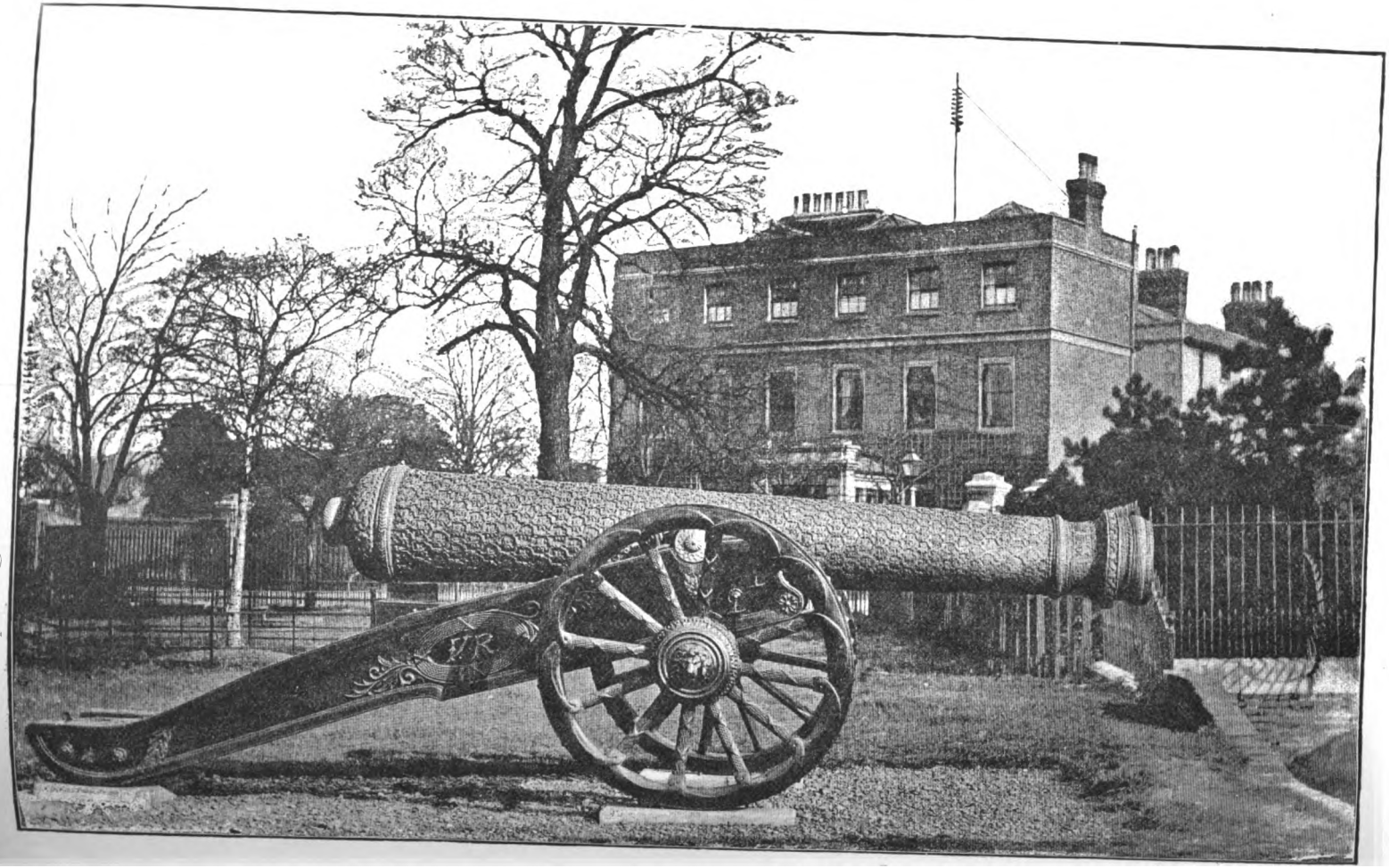

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INSCRIPTIONS

ON AN

INDIAN GUN ON THE BARRACK FIELD,

WOOLWICH,

AND THEIR INTERPRETATION.

BY

A. N. WOLLASTON, ESQ., C.I.E.

COMMUNICATED BY THE SECRETARY.

THE gun which is the subject of the following notes is now in position on an ornamental carriage at the S.-E. corner of the Barrack Field, Woolwich, opposite the Commandant's House.

It is an Indian S. B. bronze gun, the extreme length being 168·6 inches, and the estimated weight 6½ tons, calibre 5½ inches.

The workmanship is both elaborate and beautiful, and at once attracts attention; yet it is curious that though a good deal of trouble has been taken to endeavour to trace the history of the gun, which is so conspicuous from its size and beauty, there still remains much uncertainty about the identification.

It was covered with many coats of lacquer and showed little signs of the fineness of the workmanship until relieved of such covering under the direction of the Superintendent of the Royal Gun Factories in September 1885.

The balance of evidence inclines to show that it is one of several guns which stood in front of the Mess-house of the Officers of the late Bengal Artillery in Meerut, but neither the date of its removal to England nor that of its subsequent movement to present position can be discovered.

The suggestion has been made that the gun was presented by the Officers of the late Bengal Artillery on their amalgamation with the Royal Regiment, and if this be a correct surmise, it would be unfortunate to lose the record of the gift.

The circulation of this notice will perhaps bring the gun into the recollection of officers who may be able kindly to supply the facts wanting to complete its history.

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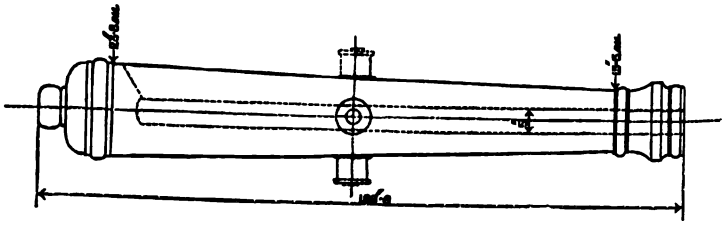
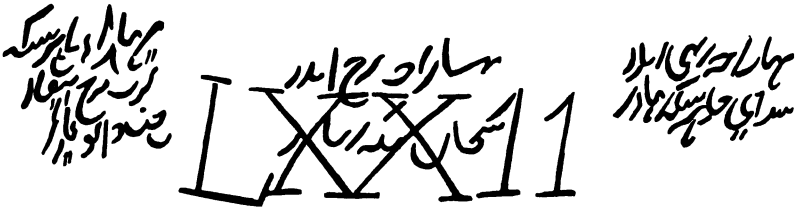
There are three inscriptions on the gun which have preserved the story of its origin and dedication.

The deciphering of these was undertaken by Mr. Wollaston of the India Office, and we are indebted to his great learning and kindness for the remarks which follow in explanation :—

5-INCH S.B. BRONZE GUN.—Scale $\frac{1}{32}$.





(3) (1) (2)

There are three inscriptions on this cannon, marked as above 1, 2, and 3.

The first is clear; given in Roman characters, it runs thus:—

"Mahárájah Brijandar Sujján Singh Bahádur." This is obviously the name of a monarch.

The second inscription is doubtful as regards the second word, which is somewhat like "Pirthí," a not uncommon name in the East, though it may be meant for "Brijí." The sentence would read (rendered into Roman characters) either "Mahárájah Pirthí Andar Siwáí Jawáhir Singh Bahádur," or "Mahárájah Brijí Andar Siwáí Jawáhir Singh Bahádur." I incline to the latter view, as "Pirthí Andar" does not sound right, at any rate it is a combination with which I have never met; the words are merely, as in the first inscription, the name of a monarch.

The third inscription is perplexing, because though there are but two words doubtful the sentence might be materially modified according to the purport of the missing links. The words which occasion embarrassment are the second and the sixth; of these the former may be either "Bábar" or by taking some of the strokes which possibly

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refer to the second line, as refering to the first line the letters might be deciphered as "Mánbhir," a familiar name in the East. "Bábar" seems improbable, as he died in *A.D.* 1530, and the gun is certainly not three hundred and fifty years old, so at a hazard I read the word "Mánbhir." As to the sixth word I confess I am sorely puzzled—at a guess however, I take the word to be "Maqám (= place or locality).

The sentence then would run thus:—(In Roman characters) "Mahárão Mánbhir Singh túp-i-burj-i-ín Maqám Sákht Wálú Kárí-gar;" which may be translated Mahárão Mánbhir Singh made the cannon of the citadel of this place Wálú (was) the artificer.

The figures LXXII. on the first inscription are obviously the work of some European, and are in no way connected with the writing.

In endeavouring to decide what is the history of the gun, the first thing which demands attention is the circumstance that at the end of the cascable there is the design of a face, intended apparently to represent either the "Sun" or the "Moon." This points strongly to the presumption that the cannon belonged to one of the dynasties known in India as the "Súryabunsí," (Children of the Sun) or "Chandrbunsí" (Children of the Moon). Now "Udaipúr" is a dynasty of the Sun, and the surmize that this is the State whence the gun came is strengthened by the fact that Sujján Singh (Inscription No. 1) does occur in the annals of that Principality; but though the British Government have several times interfered in the internal administration of the country they have never conducted warlike operations against the Chief; so I conclude that, in spite of the mark on the cascable, the cannon was not captured in this State.

The names "Siwáí" and "Pirthí" (Inscription No. 2) are to be traced in the "Jaipúr" dynasty, but so far as my researches have extended I cannot find that this line of Chiefs belongs to either the "Children of the Sun" or the "Children of the Moon;" moreover, though on more than one occasion the British authorities have taken steps to secure good government in this State, I have not succeeded in discovering any campaign of a nature likely to result in the capture and despatch to England of a cannon of this description; so I dismiss "Jaipúr" from further consideration.

There remains but one other State to which I wish to refer as in any way connected with the matter at issue,—I allude to "Bhartpúr." In the first place the ruling race is sprung from the "Játs," and these latter in turn claim an origin as "Children of the Moon;" moreover, "Brijandar" "Siwáí" and "Jawáhir Singh," are all names frequently to be met with in the annals of the Bhartpúr dynasty, while the first of the three, as far as I can learn, is confined exclusively to this State. Further, there was also a Chieftain in this Kingdom, by name Jawáhir Singh, who flourished from *A.D.* 1763 to *A.D.* 1768. Lastly, the play of words in "Brij" and "Burj," both written in Persian *b r j* (no short vowels) seems to emphasize the word "Brijandar." These various arguments seem to point strongly to the supposition

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that the cannon came from Bhartpúr, and what more natural than that this should be the case, viewing the matter from an English standpoint? There were two sieges of the citadel, one in 1805 under Lord Lake, the second in 1826 under Lord Combermere, and both were amongst the most brilliant feats of arms in the annals of India. To have sent to this country a trophy associated with campaigns so glorious would seem more or less a matter of course.

Taking therefore all the above points into consideration, I have some confidence in pronouncing the cannon as from Bhartpúr, and dating from the third quarter of the 18th century.

A. N. Wollaston,
Examiner in Persian,
R. M. College, Sandhurst.

26th October 1896.

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NOTES ON ORDNANCE

IN THE

ROTUNDA MUSEUM.

BY

LIEUTENANT S. G. HORTON, R.A.

VISITORS to the Rotunda Museum who are acquainted with the construction of the ordnance of the present day, cannot fail to be struck with the similarity existing between some of the ancient munitions of war there exhibited, and some of our so-called modern inventions.

With the help of Mr. Douglas, the custodian, I have endeavoured to make a few notes on the most striking examples.

MUZZLE-LOADING GUNS.

Amongst these are some curious specimens of coiled guns.

$\frac{1}{1}$ is a wrought-iron 15-inch bombard for throwing stone shot. This is one of the earliest examples of coiled guns, and consists of a thin shell of cast-iron, surrounded by a coil of wrought-iron. It is said to have been found in the moat of Bodiham Castle, Kent, and is at least as old as the earlier part of the 15th century.

$\frac{1}{7}$ is of very curious construction, and dates from the period of Henry VI. (1422-61). Part of the breech having been at some period broken off; it was examined in 1861 and found to consist of longitudinal bars partially welded together, with lead poured into the interstices. Over this have been driven 35 rings, which were afterwards burred down to a close joint at their edges. A bronze cylinder in the breech forms the powder chamber. This construction partakes rather of the nature of the Mallett mortar.

$\frac{6}{1}$ is a companion gun to this, and is in a very perfect state of preservation.

$\frac{2}{173}$ is an early example of a method of construction which has been brought to notice lately, viz., that of coiling a steel ribbon, under tension, round a steel cylinder. In this case the cylinder is of copper, and, instead of steel ribbon, it is surrounded by tightly coiled hempen

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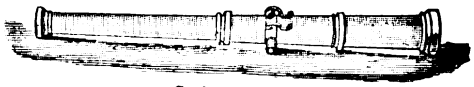
cord. It is bound round with leather and has a bronze trunnion ring with dolphins. This gun is attributed to Gustavus Adolphus.—(*Vide* Fig. 1).

Fig. 1.



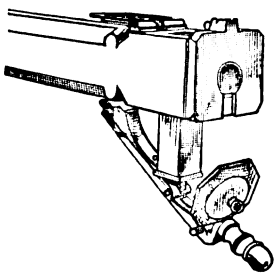
Scale about $\frac{1}{10}$.

Breech-loading guns.

We find the principle of the Armstrong vent piece working in a vertical slot in several guns of different periods.

1 **21** is a capital example. The bore is continued through the breech end, and the breech piece, which works in a vertical slot and is attached to a lever beneath, has a vent running first vertical, and then horizontal in the axis of the bore. Its date is 1619.—(*Vide* Fig. 2).

Fig. 2.



Scale about $\frac{1}{6}$.

3 **124** is another example of the same construction. In this case, too, the vent-piece is worked by a hinged lever below. It was submitted by Mr. C. Daniells in 1807.

3 **123** is a similar gun, and of about the same date.

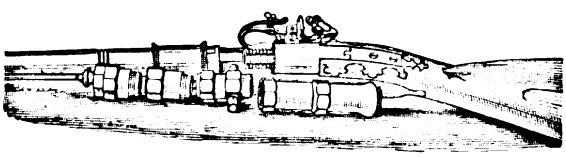
2 **160** is a brass breech-loader dated 1650, of Dutch origin, and is closed by a breech-piece, on the Wahrendorff principle, passing through a horizontal slot.

1 **23** has also a transverse slot for the breech-piece, the gun in this case being of wrought-iron in the form of a wall piece.

Jointed guns.

25 **191** Hidden away in one of the table cases, and liable to be passed unnoticed, is a model of a wrought-iron gun unscrewing into six pieces. Two of the joints however, have got set fast.—(*Vide* Fig. 3).

Fig. 3.



Scale about $\frac{1}{6}$.

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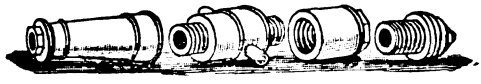
25/190 On a table against the wall nearly is a brass model of a 24-pr. M.L. gun which unscrews into four pieces.—(*Vide* Fig. 4).

FIG. 4.



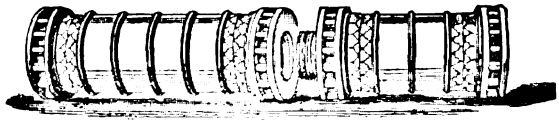
Scale about $\frac{1}{8}$.

25/192 On the opposite side of the room, in a table case, is a very small model of a brass gun, externally cylindrical, unscrewing also into four pieces.

These are all analogous to our jointed 7-pr. mountain gun, and to the jointed howitzers which have been experimented with recently.

1/189 is a large brass gun, unscrewing into two pieces, brought from the Dardanelles in 1867, and cast in 1468. It would seem however that this was as much for convenience in manufacture as for portability.—(*Vide* Fig. 5).

FIG. 5.



Scale about $\frac{1}{96}$

MACHINE GUNS.

Now that machine guns have taken so prominent a position amongst our ordnance, it is interesting to note the attempts of our forefathers to produce something of the sort.

The Gatling gun finds its representative in **2/172**, of which the following description appears in the catalogue—"A curiously constructed brass gun of seven bores, without date, but probably referable to the period of the 30 years' war. It is made to revolve in a collar at the centre. Two arms extend from this collar to the breech, and were evidently made to be fixed to a part of the carriage, which carried a wheel, fitting teeth, on the breech of the gun, by which it was rotated about its axis in the collar abovenamed. The dolphins and trunnions are on the socket. There are seven vents, quite distinct, and there was originally a cover to each of them . . . . . Length 3 ft. 9½ ins., calibre of all the bores 1·68 inch."

10/8 is a rifle battery designed in 1854 by Sir J. Lillie, and consisting of twelve barrels in two tiers of six each, having revolving chamber blocks, the upper ones with twelve chambers in each, and the lower ones with twenty. The barrels are fired by means of a shaft operated by a winch to each tier, and on which are cams, firing the barrels from right to left, and revolving the chambers also.

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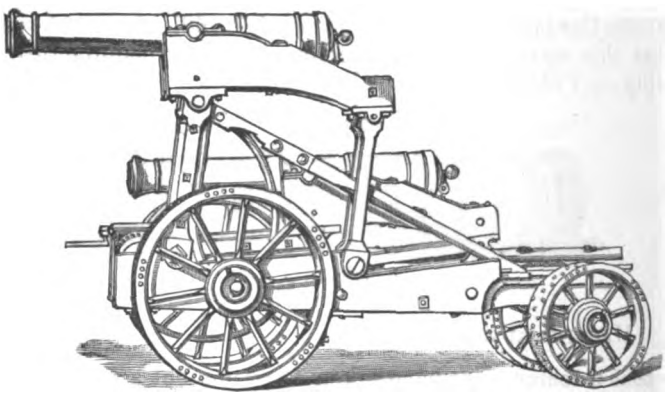
10/7 is also a rifle battery, though described in the catalogue as an "infernal machine." It consists of 31 rifle barrels, fixed in a frame, and having a frame of brass chambers which drops in in rear and which chambers are discharged simultaneously by means of one percussion cap, which ignites powder in a channel communicating with all the chambers.

Disappearing carriages.

There are several examples of these, of which the most remarkable is **25/27**; on this are mounted a pair of twin guns each on a separate top-carriage, which is wound up to the firing position by means of tackle and a winch, and supported by a prop behind. Date unknown, but very old.—(*Vide* Fig. 6).

Fig. 6.



Scale about ⅛.

Interrupted breech screw.

9/9 is an early example of the interrupted screw, in this case applied to a flint and matchlock musket, made at Mayence about the time of Marshal Vauban (*circa* 1690). The muzzle portion turns round one-sixth of a circle, and then pulls out a short distance, liberating the breech-piece, which can be thrown back on a hinge. (*Vide* Fig. 3).

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SHORT HISTORY AND DESCRIPTION OF ARMOUR

AND ITS

ATTACK BY ARTILLERY.

BY

CAPTAIN C. ORDE BROWNE, LATE R.A.

(Continued from No. 15, Vol. XIV., p. 658).

CHAPTER XI.

ARMOURED STRUCTURES.—FORTS.

ARMOUR has been applied by our English Engineers to coast forts only, though in some cases it may be specially valuable inland. Coast forts would generally be assailed by heavier guns than would be employed in a siege. On the other hand, an armoured fort inland would be liable to be attacked more persistently and systematically than could well happen in the case of a coast fort. Thus, it naturally follows that wrought-iron is admirably suited for inland works,[1] while chilled-iron has been chiefly employed for coast defences.[2]

Under the head of chilled-iron, the principal classes of cupolas and batteries of Grüson's armour have been briefly described (*vide* p. 625, Vol. XIV.), and it has been pointed out that England differs from other powers in having her coast forts protected with wrought-iron armour, which, although it may be in a measure re-inforced or superseded by compound armour, will for a long time to come form the main fabric of our shields. A brief description of the classes of the structures used on the coast of England, together with what has been already given on Grüson's chilled-iron shields, will be sufficient for the purpose in hand. The following is taken from a paper read by General Inglis at the Royal Artillery Institution, which dealt much more fully with the subject :—[3]

The armour takes four forms.—(1.) *Casemate shields built in masonry.* (2.) *Shields in masonry, with guns on turntables.* (3.) *Iron batteries.*[4] (4.) *Turret.*

---

[1] *Vide* Bucharest trials.

[2] The Alpine shields, noticed in p. 629, Vol. XIV., are perhaps almost the only case of chilled-iron shields adopted for inland defence. The peculiar action of wrought-iron and its value against continued fire, as compared with chilled-iron, is illustrated in Krupp's Meppen trials of 1879, *vide* p. 282, Vol. XIV.

[3] Read at R. A. Institution, April 29, 1880.—*Vide Engineer*, May 6, 1881, p. 326.

[4] That is, a battery whose entire walls are iron-armoured.

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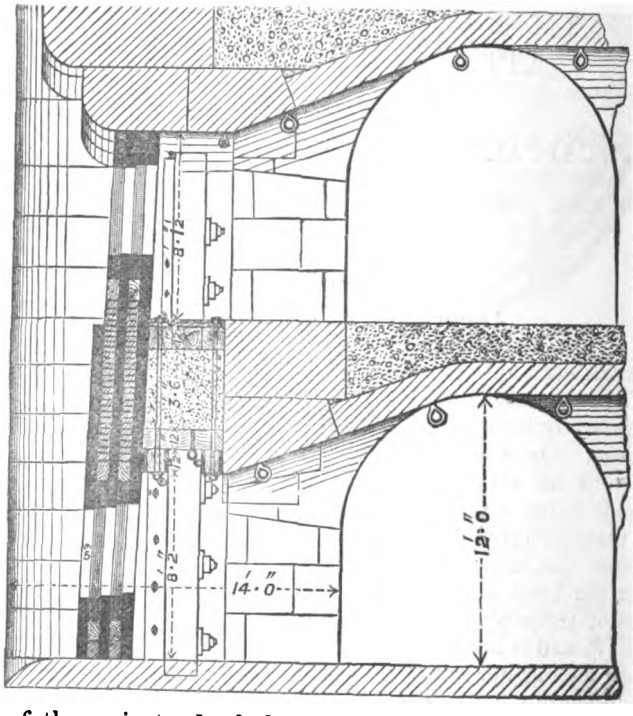
Casemate shields.

Casemate shields in masonry.—Fig. 1 gives a section of Picklecombe and Garrison Point forts as a specimen of two-tier shield fixed in masonry, showing however a comparatively weak sample. At Garrison Point, Sheerness, the 38-ton guns have three 10-inch plates

FIG. 1.



in front of them, instead of three 5-inch. Speaking generally, the shields are built into the masonry in the following way;—A strong frame of ¾-in. plate, and 6-in. × 6-in. angle-irons is constructed in the masonry, being built in, and attached by bolts, dove-tailed pieces, &c. On this is built the armour, generally on the plate-upon-plate system. Between the inner plate and the shield frame there is an inch interval usually filled with wood.[1] The drawing explains itself.

Shields in masonry with guns on turntables.

Fig. 2, p. 305, shows a specimen of turntable battery (Class 2), such as that at Helen's Fort, Portsmouth, Malta and Gibraltar. They occur where a lateral fire extending through about 120° is required. Each gun has two ports, and moves to either by means of the turntable. Here again the example taken is a weak one of its class, although the structure is strengthened by intermediate layers at the ports, and heavy iron-cased concrete supports between the ports. Three 6-in. or two 9-in. plates are used in some places.

[1] Each thickness of armour is bolted to the one next behind it, and the rear plate to the shield frame.

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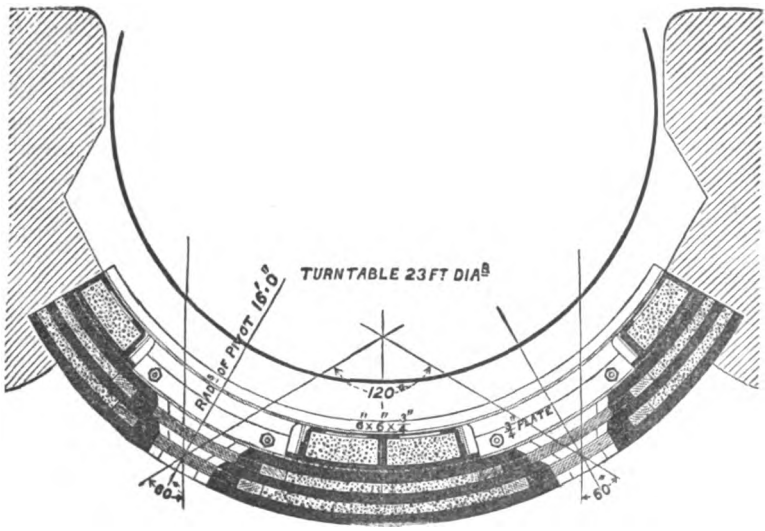
FIG. 2.



Shields and turntable.

Omitting Plymouth Breakwater, which is a stronger but perhaps less interesting structure, (Class 3) may next be taken. *Iron batteries*, of which the two great forts of Spithead, *Horse Sands* and *No Man's Land*, are good specimens (*vide* 3). Here again may be seen the

Iron batteries.

FIG. 3.

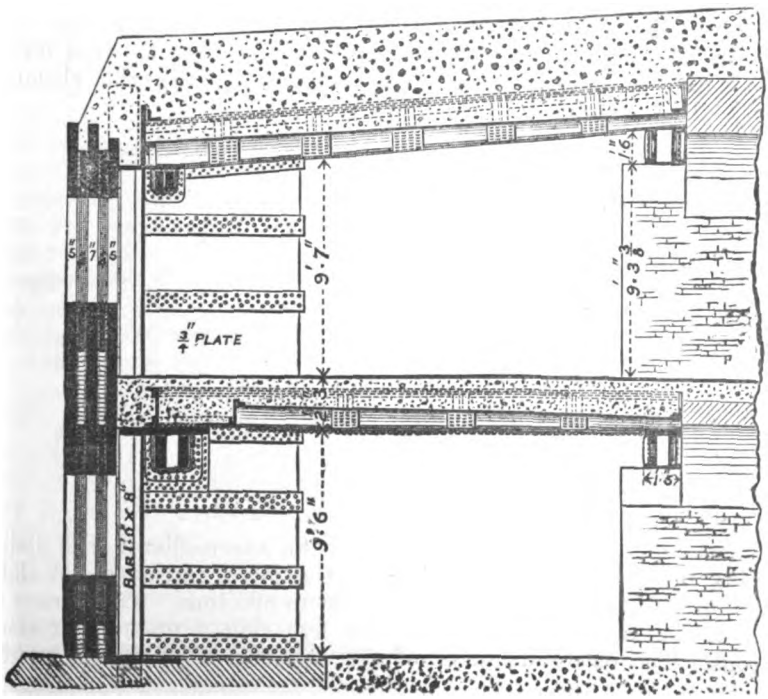


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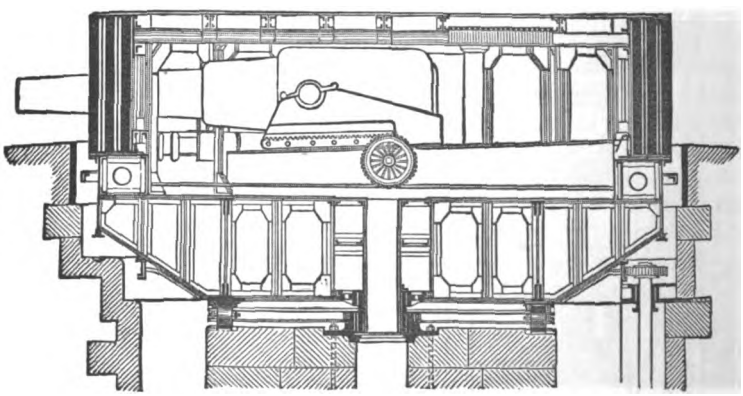
plate-upon-plate armour, coupled with the principle of keeping the armour separate from the floor structure, so that any contortion of the armour may not affect the racers or structural parts on which the working of the guns vitally depends. There are armour bar supports about 10 ins. × 5 ins. × 4 ins., the greatest section of each being placed normally or radially to the wall, about four inches apart, extending from the lower floor to the roof. The pier cases are filled with Portland cement concrete. The safe load of the upper gun floor and of the roof is equal to a mass of concrete laid 10 feet thick over it, or half a ton on every square foot. The middle plates of the armour stand on end, being 22 ft. 6 ins. long, extending from base to roof. Concrete is used between the plates except at the port frames, where wood is employed. It may be seen that here again it would be easy to add outside rings of armour and masonry to correspond, for which work, express provision is made. The weight of iron work on these forts is as follows:—skeleton per gun, 50 tons, total 2450 tons: armour wall per gun, 75 tons, total 3764 tons; total weight, 6214 tons. Each sea fort at Spithead, Spitbank and Plymouth is prepared for the addition hereafter of turrets on its roof, each to carry two of the heaviest ordnance. The Spithead forts can carry five turrets each; the others two each. Rope mantlets soaked in chloride of calcium, to render them uninflammable, are supplied to all these works.

Class 4 *turret* is only employed on Dover Admiralty Pier. This is a tremendous structure. The foundations are laid 7 fathoms below low-water mark, and the guns are 33 feet above high-water mark. The entire structure is therefore about 95 feet high. The turret consists of a live ring and rollers of steel running on a path of steel laid on a massive cylinder of masonry. On this live ring runs the iron framework (Fig. 4), weighing 240 tons, containing the gun chamber.

FIG. 4.



The armour consists of three 7-inch and two intermediate 2-inch plates, making in all a weight of 460 tons; the guns, carriages and slides make up the total of the running weight to 895 tons. This throws on each of the thirty-two rollers of the live ring a pressure of about 28 tons. The entire diameter of the turret is 37 feet, the interior

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32 feet. The interior height of the gun chamber is 8 ft. 8 ins., the height of the turret armour is 9 feet. There is a massive central casting holding on to the masonry, and a thick cylinder of hammered Bessemer steel inside this surrounds the wrought-iron built-up cylinder, which forms the centre of the turret framework. The unabsorbed portion of the blows of impact may be transmitted to this part which is made specially strong. The pieces are 80-ton guns, got in and out through the roof, of which parts are made removable for this purpose. Provision is made for the escape of smoke through the turret top. The gun ports admit of 7° elevation and 2° depression. The glacis round the turret is plated with 5-inch and 3-inch plates. The guns are loaded from under the glacis, the muzzles being depressed for the operation.

Throughout the works, above described, the probability of continual increase being called for, has been kept ever in view. This has augmented the difficulties under which the Engineers have laboured. This system of coast defence may naturally be compared with that of Grüson. In doing so it must be borne in mind that breech-loading has enormously facilitated the construction of strong forts, because, as may be seen in Fig. 6, p. 630, Vol. XIV., it is only necessary to give the men sufficient height to stand upright some distance back from the wall instead of close to the port as with muzzle-loading. Hence, the forts for muzzle-loaders must of necessity be carried in a cylindrical form higher than those for breech-loaders, which may be curved back into a dome, thus saving wall and giving greater strength to the roof. Moreover, on most systems,[1] much more space is occupied by the working of a muzzle-loader, which must be run back further than a breech-loader. A conical turret with steel-faced armour was tried at Eastbourne, in May, 1886, but is as yet in a very imperfect condition. In justice to Grüson, it must be noticed that casting lends itself to the shaping of a dome with each part proportioned to the work that it is calculated it may have to bear in a way that no system of plates made by rolling or hammering could claim to do. Probably the English forts altogether cost much more than those of Grüson.

Provision for increase.

In their favour must be urged that they will bear continued fire better,[2] and that it is very easy to increase their strength by adding plates in front of their armour, for which complete provision is made, even to the drilling of holes and insertion of nuts and temporary bolts, to enable the operation to be performed without removing even the front plate. Grüson's cupolas must, it is supposed, be broken up and re-cast in order to increase their strength. With the powers of Artillery ever growing this is a very important consideration. Further, it is obvious that the plate-upon-plate system favours the removal of plates from one part to another readily if wished, an operation that in certain cases might be desirable. *Under the attack of a gun completely beyond the power of the fort,* the wrought-iron would be perforated, and the shell would pass on doing mischief, though in the case of fairly

[1] Rendell's system of lowering the muzzle and loading below the glacis may save both in height above the port and in running back.

[2] *See* pp. 429, 434, Vol. XIII., and 283, Vol. XIV.

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thick steel-faced armour it would be in the form of dead metal, for shells that pass through such armour before exploding are far from realization at present.[1] Chilled-iron, under these circumstances would probably stop every part of the projectile, possibly at the price of its own wholesale destruction, but so long as the wall is fairly whole the men need not fear the next round. Lastly, the vertical walls of our coast forts enable tiers of guns to be mounted one over the other, so as to utilize the area of the foundation to the fullest extent.

CHAPTER XII.

Brief Summary of Behaviour of Various Kinds of Plates, Backing, &c.

Wrought-iron.

1. *Wrought-iron* yields locally; it is punched or perforated, a clean hole being made in it.[2] The rest of the target hardly suffers appreciably, except close to the point of impact. The entire shield, including bolts, is generally capable of resisting any subsequent blow as stoutly as it resisted the first one. Effect here must be obviously produced by the bare power of perforation of each round taken singly. Partial penetration is practically useless, however often it may be repeated.[3] The shot experiences but little resistance as its point enters, and hence it is well enclosed and supported round its head before the full strain comes on it. Hardness and rigidity of metal in the projectile here tell to the greatest extent, and tenacity to the least. These conditions have favoured the use of Palliser's chilled-iron shot with sharp points. The plate yields at the back opposite to the point of impact by tearing in a cross or star line, letting the point of the shot through the centre.

Steel-faced iron.

2. *Steel-faced wrought-iron,* Cammell's, made on Wilson's patent, or Brown's on Ellis' patent. Here the steel face, which constitutes about one-third of the thickness of the plate, is a harder class of steel than is generally supposed,[4] and resists the point of the shot abruptly, and severely tries the tenacity of its metal. Hitherto, seldom has a projectile held together under these conditions;[5] there is a mechanical force acting something like the outward thrust on the sides of an arch, and the shot sets up, or more commonly breaks to pieces, leaving but little metal lodged in the plate. The plate yields mainly by cracking in radiating lines from the point of impact. In plates badly backed the plate bends slightly back, and very rigid shot occasionally get their points through; but when well backed, the entire plate must be broken

[1] The excellent Krupp shells, and those of *Firminy* and *Holtzer* fired at Shoeburyness in the summer of 1886 promise well, but a good deal has yet to be done before they carry bursting charges through steel-faced armour, more especially on service, when they would hardly ever strike normally.

[2] *Vide* p. 434, Vol. XIII.

[3] *Vide* p. 426, Vol. XIII.

[4] Containing perhaps about 0·7 per cent. of carbon.—*Vide* p. 398, Vol. XIV.

[5] Firminy and Holtzer forged steel projectiles fired from the 12-inch B.L. gun, passed through 16-inch steel faced plates without fracture in the summer of 1886.

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in pieces and displaced before a shot gets past it in any sense. In addition to the radial cracks, concentric ones are apt to be developed, sometimes, perhaps, owing to the tendency of the plate to give back about the point of impact. Obviously, here tenacity in the shot is called for in a much greater degree than with wrought-iron armour.[1]

Solid steel.

3. *Solid steel*, as made by Schneider[2] and used in many foreign ships, though rather less hard than the steel face of compound plates, is as a mass more rigid. It admits the point of the shot at first with less resistance, but it does not yield at the point of impact even when badly backed, and is, therefore, less dependent on backing than compound armour. As the shot enters, it wedges and heaps up the metal round it, the plate coming forward and swelling at the point of impact and yielding by radiating cracks. It may be questioned if a case could be found of a concentric crack being made in steel armour. Nearly all cracks made extend through the metal, but by the employment of a large number of bolts the fragments may be held up, and considerable resisting power maintained after fracture. On the other hand very soft steel plates admit of perforation, and in their character resemble wrought-iron more or less.

Grüson's Chilled Iron.

4. *Chilled-iron* made by Grüson,[3] and used almost universally in foreign coast-armoured defences, is very rigid indeed. The shot seldom gets its point many inches into the metal. The shield transmits the shock through its mass and must be broken up bodily. Chilled-iron is used in large masses, and is best suited to resist single blows, especially in an oblique direction. Under the direct blows of heavy shot of high tenacity, chilled-iron breaks up. Cracks radiating from the point of impact are formed, and the whole shield breaks across. An important requirement in the shot appears to be tenacity, to enable it to deliver its work on the point of impact before it breaks up, which it does, leaving little or no metal lodged in the shield.[4] The best forged steel projectiles shiver to pieces against Grüson's shields. The hardness of the metal and the angle presented by the surface to the line of fire alike tend to produce this result.

Backing.

Backing strengthens the plate to resist perforation better when hard, but saves bolts and fastenings from fracture better when soft. Thus steel-faced iron on granite has resisted perforation wonderfully.

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[1] For compound steel *vide* p. 314.

[2] *Vide* pp. 398, 413, 427 and 431, Vol. XIV. A very remarkable series of experiments was made under Sir Nathaniel Barnaby's direction at Messrs Cammell's, Cyclops Works, Sheffield, in Nov., 1880, on the bending of steel plates of thicknesses of an inch and less, when it was found that steel bending well both at red heat and cold would in no single instance bend without tearing, at blue heat. Cammell's, Brown's, Bolton, Parkhead, Landore, Siemen's, and Steel Company of Scotland steel being experimented on. The author called the attention of manufacturers on different occasions to this, especially with a view to steel boilers. Messrs. Hawthorne's, Newcastle, found evidence of the same tendency in iron. It may be observed that it is not proved that the metal yields under less force at blue heat, but only that it prefers to tear rather than bend when it does yield at that temperature.

[3] *Vide* pp. 625 to 658, Vol. XIV.

[4] For chipping the face by concave pointed shot *see* pp. 637 and 640, Vol. XIV.

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(*vide* p. 139, Vol. XIV.). For iron, concrete, brick, &c., (*vide* p. 431, Vol. XIII.). Wood layers between plates (*vide* p. 431, Vol. XIII.). Air spaces between plates of armour, have the effect of breaking up chilled-iron shot (*vide* pp. 431, Vol. XIII., and 128, Vol. XIV.).

Bolts.

Bolts should resist sudden shocks and bear elongation well. The early ships[1] had through bolts with conical heads holding into the armour and screwed ends nutted against the skin (*vide* p. 427, Vol. XIII.). French bolts had wood screws with projecting threads holding into the backing (*vide* p. 427, Vol. XIII.). Palliser bolt with projecting thread was proposed in 1862, and eventually took the form of the *Palliser-English* bolt with shank decreased to be free from all nipping to prevent local strain and with spherical screw nut fitting into hemispherical bottomed socket to accommodate itself to slight lateral displacement (*vide* p. 428, Vol. XIII.). These are used to couple iron plates together in pairs on the plate-upon-plate system. For steel plates Schneider introduced a screw entering a short distance into the back of the plate[2] and leaving the surface and, indeed, the mass of the plate unperforated (*vide* p. 428, Vol. XIII.). These bolts are screwed and nutted at the reverse end.[3] In cases where the backing is thin the bolt would suffer, by being too short to give scope for elongation. This evil is counteracted by using an iron pipe-box on the back of the shield through which the bolt is made to pass. This enables it to be prolonged to the necessary length to meet the required stretch, without an unreasonable per-centage of elongation. A hollow iron washer filled up with india-rubber is nutted on to the bolt end. This bears on the end of the pipe-box. Bolts are now generally made of soft steel. They are proved by being stretched by the fall of a heavy weight on a frame held up by a bolt.

CHAPTER XIII.

Brief Notes on Manufacture.

The manufacturing processes employed in making armour and projectiles form too large a subject to be attempted here, and in all probability the most important features are just those that the manufacturers would not wish to publish. Nothing therefore is here attempted beyond a brief sketch, indicating the general character of the processes of manufacture of different kinds of armour. They are taken in historical order.

Wrought-iron.

Armour, wrought-iron.—General Inglis gives the following description, which is quoted verbatim :—[4]

"For this, as made at Sheffield, the best cold-blast pig with a proportion of Cumberland hæmatite is generally used. Roughly

[1] The *Warrior*, *Minotaur*, &c.

[2] At Spezia in 1882, Schneider's bolts only entered 2¾ inches into the 19-inch plate (p. 398, Vol. XIV.).

[3] For behaviour of shot, *see* manufacture, p. 325.

[4] Paper read at R. A. Institution, April 29, 1880.

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speaking, it takes 2½ tons of pig, or 2 tons of ball furnaced iron—that is, of puddle ball—to make 1 ton of finished armour plate, and in the last heating of all, when the iron is in a very costly state, there is a loss by the actual burning away of the iron of about 10 per cent. It takes also about 6½ tons of coal to make a ton of armour.

Perhaps the shortest way of giving an account of the manufacture of rolled iron armour will be to say how some one plate in particular has been made, and for this purpose one of the heaviest ever produced is selected.

This was one of the 8-in. plates made for the target to test the 80-ton gun at Shoeburyness. Its finished dimensions were—length 16 ft., width 10 ft., and its weight 23 tons.

For its manufacture 1170 slabs 30 ins. long, 12 ins. wide, and 1-in. thick were made from the puddled ball and bar. These were piled, furnaced, and rolled into 65 plates about 5 ft. square, and from 1-in. to 1½-in. thick, called small moulds. These, again, were piled and rolled into quarter-moulds, and the quarter-moulds into armour-plate moulds, and the pile for the last rolling was made up of three moulds about 10 ft. square, two of 7 ins. and one of 3 ins. thickness. As they entered the furnace for this last heating they weighed about 35 tons; as they came out after about 12 hours they weighed 31½ tons.

They were rolled down in the last rolling from 17 ins. to 8 ins.; so that, in a certain sense, this plate may be said to have been made by rolling a column of iron nearly 100 ft. high down to one only 8 ins. high. The fibrous character of a plate depends largely upon the amount of reduction in the last rolling.

The rolls are plain cast cylinders; those used in the present case are about 3 ft. in diameter, 12 ft. long, and each one of the pair weighs nearly 20 tons. They are driven by very powerful steam machinery, and made to reverse their running, so that the plates are sent through one way and then back again, and so on, the rolls being brought nearer together each time, until the plate is brought down to the required thickness.

The specific gravity of a good iron armour plate is about 7·625.[1]

Armour plate iron is not made for very high tensile strength, but it

[1] Contradictory statements are made on this matter. Dr. Percy (*Iron and Steel*, p. 868) gives the specific gravity of wrought-iron before rolling as 7·877, and after rolling as 7·86. Sheffield manufacturers have told the author that the specific gravity is increased by rolling, not decreased. It will be seen however that the specific gravity given by General Inglis, 7·625, is considerably less than that by Dr. Percy, in fact, it agrees with what he gives for thin sheet, namely, 7·6. This suggests that the plates are very well rolled, and that Dr. Percy is correct. On the other hand, Sir F. Abel, in a paper read at the Iron and Steel Institute, in October, 1886, on erosion, considered that steel of 7·859 specific gravity had been worked more than one of 7·847. If however the specific gravity is decreased it must be presumed to be due to the fact that the crystals being elongated enormously, the intervals between them occupy a larger proportion of the area of any cross section. There seems nothing unreasonable in this, though doubtless Sir J. Whitworth would have considered that it supported his view that wrought-iron consists of faggots of iron glued together with cinder. This fibrous structure ought however to offer advantages. Dr. Percy states that it is twice as easy to break it along the fibre as across it. As the fibre would run with the length of the plate it would give the plates the maximum strength in the narrowest direction and make it very difficult to break them across.

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is essential that it should draw out well, and reduce in cross section some 20 or 30 per cent. before breaking.

It has been our practice to prove a very large proportion of the plates made for iron fortifications by shot capable of nearly perforating them. Pieces of those which could not be thus proved have been broken under hydraulic presses, and otherwise treated.

Armour bolt-iron is similar to armour plate-iron (but soft steel is now much used). We require reduction of area of fracture of at least 40 per cent. when broken by falling weight test, and we generally get a larger reduction than this.

Laminated armour.

In the early days of armour, *laminated armour* was used in America to meet the requirements of the moment. This consisted of thin sheets of iron bolted together. These sheets, sliding on each other, facilitated the work of punching, especially by pointed projectiles, because the corners of the torn metal bent back much more easily than is the case with solid plate, and accommodate themselves to the bend. The measure in which plate-upon-plate armour is inferior to equally sound solid plate must be explained on the same principle, a slight inferiority which is thought to be amply compensated by the advantages of breaking joint, and larger surfaces with fewer joints, &c.

Steel-faced iron

A compound or steel-faced plate consists of a wrought-iron "foundation plate" with a steel "face plate" of about half its thickness attached to the front, thus giving the combination of hard surface[1] and tough back or body. There are two processes on which this class of armour is made namely:—Wilson's, carried on by Messrs. Cammell at the Cyclops Works, and Ellis', by the firm of Sir John Brown and Co., at the Atlas Works, both at Sheffield.

Wilson's System.

Wilson's system was first brought into practice, and has been taken up by several firms on the continent. The foundation plate consists of thinner plates each made up separately and finally united, but not thoroughly worked up and amalgamated. It is thought better to keep up the laminated structure sufficiently to cause these layers to break and yield separately, and not in one continuous line. It will generally be found that when a shot destroys a plate of this kind, the layers tear open in steps, any breach made becoming larger and larger as it reaches the back of the plate. It is held that increased resistance is offered by a fracture of this kind, and much more support afforded by the backing.

When the foundation plate has been completed it is at once cleaned of scale, passed into a mould and secured at its edges. The mould is then rotated so as to be up-ended, and steel is poured in to form the face plate. After this, the plate is rolled and finished.

Ellis' System

On Ellis' system, the foundation plate is more completely worked, and when ready for the steel face, it is laid horizontally, and the thin steel plate which is to form the front of the shield is laid on it, being held up at the proper distance to allow of the molten

[1] At Spezia in 1882, Brown's steel-face had 0·7 per cent. carbon and Cammell's 0·65, *vide* p. 308.

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steel entering between the two, by resting on a number of steel pins standing on end. The two plates in this state are passed into a furnace, and when heated are brought out, placed in a mould, and steel is run in between them after they are brought to the vertical position, as in the Wilson process. The steel pins are so far welded to the plates in the furnace that there is no fear of the two plates altering their relative position, or the pins becoming dislodged, and it is probable that they are melted by the molten steel when it is run in. The plate is then finished by rolling to final dimensions. When a plate is required to be tapered towards one edge it is necessary to narrow the space for the molten steel at this part, and to make the iron proportionately thick, for working purposes. Finally, the extra iron is cut away from the back. Fig. 5, herewith,[1] shows the running in of the steel on a foundation plate at Brown's works. A view of the same process at Cammell's would resemble it.

FIG. 5.

For Wilson's process is claimed special soundness in the body of steel, and power to remove the scale, which interferes with the union of the steel and iron, and also that one re-heating is saved. For Ellis' it is

[1] Taken from Major Mackinlay's paper to the R.A. Institution, p. 604, Vol. XII.

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claimed that the face is specially good. This is illustrated by the sharp angles at which the plates may be bent without cracking, angles at which wrought-iron is liable to give way. Under fire, Wilson's plates are softer than Ellis'. Thus penetration is deeper and cracking less in the former than in the latter. Great stress is laid on want of homogeneity by both makers. This should be understood, because this quality, which is aimed at and claimed as a virtue, is pointed out as an evil inseparable from the system by some writers, especially by Lieut. Jacques, U. S. Navy, in an able pamphlet termed "Modern Armor for National Defence." It is believed that while it is desirable to unite the surfaces of the steel and iron as perfectly as possible, the different nature of the substance of the iron causes cracks to stop abruptly, which would otherwise have run through the mass. Figs. 1 and 2, p. 315, are remarkable illustrations of this action. They represent Wilson's steel-faced plates tested at Amager, on Aug. 6th and Sept. 10th, 1885, 5 ft. square by 11·5 inches thick. The steel was 4⅛ inches, and the iron 7⅜ inches thick. The plates were actually cut in two to furnish sections after the trial. Fig. 1 shows the effect of a 10-inch chilled-iron Ankarsrum projectile, weight 181·5 kg. (400 lbs.), with a striking velocity of 423·6 m. (1390 feet) an energy of 1660 metre-tons (5358 foot-tons), a perforation of 13·4 ins. of iron, an energy per ton of plate of about 1040 foot-tons, supposing the plate to weigh 5·15 tons. A few face cracks were formed, and the behaviour of plate in stopping the shot is most satisfactory.

Fig. 2 is a more important example, because a forged steel projectile was fired weighing 182·5 kg. (402 lbs.) with a striking velocity of 438 m. (1437 ft.) an energy of 1784 metre-tons (5760 foot-tons) a perforation of 13·9 ins. of iron, and energy per ton of plate of 1118 foot-tons. The steel shot would deliver a much larger proportion of its energy on the plate before breaking up. A plate seldom survives a *single blow* of 1000 foot-tons per ton of plate. The behaviour of this plate, which is only slightly cracked at the back, is admirable.

It naturally suggests itself that compound plates might be made with very hard steel faces, and backs of soft steel instead of iron, seeing that soft steel has both greater elongation and also greater tenacity than iron. Experiments of this kind have been made at Sheffield but without success.

Sir J. Brown and Co. once tried a steel front and back with an intermediate layer of wrought-iron. The steel, however, was not soft at the back, and no great stress should be laid on this trial, which was merely one to test the effect of a break in homogeneity, on a steel plate. Two more important experiments, however, were made as follows:—Messrs. Cammell made a plate, on the compound principle, wholly of steel—that is to say, with hard steel in front and soft steel behind. The steel face had a breaking strain of about 47 tons per square inch, and an elongation of about 1·5 per cent.; whereas the back had about 23·0 tons tenacity, and 25 per cent. elongation. This plate was fired at on board the *Nettle*, at Portsmouth, on March 14th, 1884, under an experimental title. Its dimensions were 8 ft. by 6 ft. by 10½ ins. thick. It was attacked by a 10-inch muzzle-loading gun,

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Fig. 1.

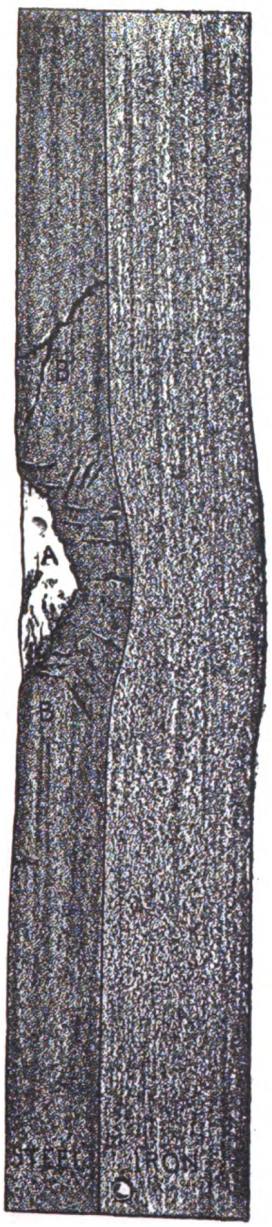
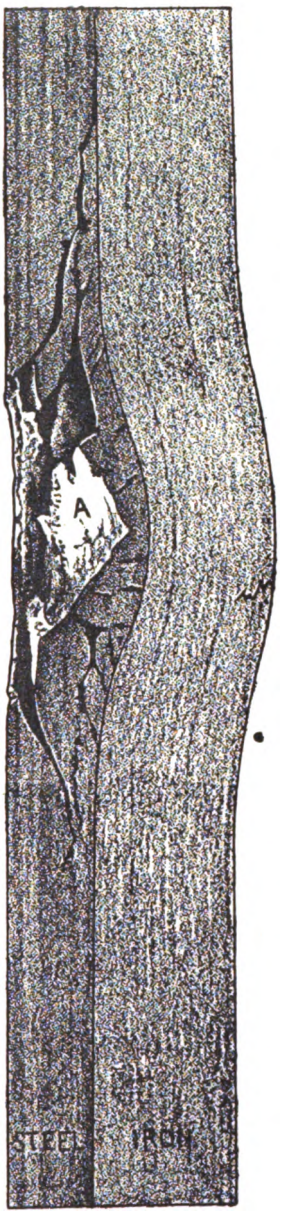


Fig. 2.



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with a chilled-iron projectile weighing 400 lb., and a striking velocity of 1364 ft. This would give a total striking energy of 5160 foot-tons, or about 573 foot-tons per ton of plate, supposing the plate to weigh about 9 tons. The calculated perforation would be about 13 ins. of iron, or 9·8 ins. of compound armour or steel. Three blows were delivered on it. The plate stopped the shot well, the projectiles only entering to a depth of about 5 ins. Nevertheless, it did not behave in a way that would meet with approval with English authorities, seeing that it cracked all over in through cracks—*vide* Figs. 1, herewith, and 2, p. 317. It remained held up by its bolts, but was divided into pieces, and was not considered sufficiently satisfactory to encourage further trials in the same direction at the time.

It may be here said that, on the first success of steel at Spezia, it was proposed to try it in this country; but our combatant naval

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advisers positively objected to it, on the ground that it stripped off, and would leave a ship's side bare. It is easy to employ a great number of bolts in a target, but on a ship's side the multiplication of bolts involves expense and weight in the supporting structure. Thus steel-faced armour was only approved on its fulfilling certain rigid conditions—namely, that no through cracks shall be made by the first round fired; it being also stipulated that no one of three projectiles shall get through the plate.

FIG 2.

The experiment with compound steel is especially to be noticed, because it had embodied in it the elements above suggested—namely, a hard face, and a back consisting of steel of greater elongation and higher tenacity than the wrought-iron usually employed, whose

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tenacity is generally about 17 tons, and its elongation 18 per cent. A single trial is doubtless hardly likely to meet with a large measure of success. Still, Messrs. Cammell are old steel makers, and their first attempt, based on manufacturing investigations, ought to be very good for a first trial. The exact measure of success, however, is not the matter of real significance, but rather the fact that will appear further on—that the behaviour of this steel plate very closely resembled that of Messrs. Schneider's steel plates at Gâvre, and would probably have passed and been accepted by the French Government. So long as such a plate meets with disapproval from our own authorities, there is very little to encourage the further trial of steel. But of this, more presently.

The second significant experiment above-mentioned, was the trial of a compound plate by Sir John Brown and Co., with a wrought-iron back differing from the usual sample, in the fact that the tenacity and elongation of the iron used were both considerably greater. Consequently it might be expected that the plate would have been both stronger and tougher than usual. It happened, however, that it cracked instead of bulging. This result, taken in conjunction with that obtained with Cammell's steel, seems to show that *low* tenacity is a necessity for the metal in the back of a plate, if it is to be kept from cracking through. Probably the action of the blow is too rapid to admit of the plate bending and stretching, unless the tenacity is low. The great power of elongation is consequently useless under impact, unless the plate elongates with but little resistance.

Solid steel. Steel armour has been made experimentally in this country by Sir J. Whitworth (*vide* p. 226, Vol. XIV), and also in thin plates supplied for service, as in the turtle back scales which cover the *Polyphemus* (*vide* Fig. 12, p. 338). The best heavy steel armour, however, has been made abroad at Messrs. Schneider's works at Creusôt. The steel is not generally so hard as that employed in the face plates of compound armour.[1] It is hammered down from a great thickness under a 100-ton hammer. It is annealed and the face tempered in oil, so it is said—but it is difficult to get authentic information—and finally annealed again. It is difficult to do justice to steel armour in England. Messrs. Schneider not unnaturally decline to supply plates for competition in this country unless a large order is guaranteed to them. It is desirable however to say something on the subject. It appears that solid steel plates can be made soft, to behave more or less like wrought-iron, or they can be made hard, in which case they resist penetration well, but break through. Hence it will be found that Schneider insists on a great number of bolts, which hold up the fragments and enable the plate to offer great resistance after it is broken through.

Schneider's steel armour.

Gâvre trials. Photographs may be seen of plates fired at at Gâvre for the French Government, which were passed as samples of lots to be accepted, which would probably have been rejected by our own authorities. They are plates of 18 inches thick and over. Unfortunately we have tried our

[1] At Spezia, in 1882, Schneider's plate was said to contain about 0·45 per cent. of carbon. It was hammered down from a thickness of 7 feet to one of 19 inches (*vide* p. 398, Vol. XIV).

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18-inch plates but seldom in this country. There has no gun larger than a 10-inch muzzle-loader been fired on board the *Nettle* we believe; and, strange as it may appear, our supply of 18 in. plates can hardly be said to have been proved at Shoeburyness or anywhere else. 18-in. experimental plates have been attacked at Shoeburyness, but this is not the same thing as the sample plates being tested and passed in the usual way for each lot supplied to our ships. The omission of a test, however, is one thing; the approval of plates of proved inferior power is another. Figs. 3, herewith, and 4, p. 320, show the front after the 2nd and 3rd blows, and Fig. 5, shows the back of a solid steel Schneider plate, the sample of the second lot of plates which were tested for the French Government at Gâvre and delivered for the *Terrible* during 1881 and 1882. This sample is selected because a view of the back as well as of the front is taken. The thickness of the plate was presumably 19·5 ins., the plate being for the belt of the ship. It was attacked by a 32^{cm} (12·6-in.) gun; the weight of the projectile was

therefore probably 761 lb. The striking velocities of the three rounds 1430·8 ft., 1430·8 ft., and 1504 ft.[1] The projectile was a chilled shot, as may be seen in the engraving, from the white radiating splashes of metal. The gun is not a match for the plate. The perforation would

[1] E = 11930 foot-tons.

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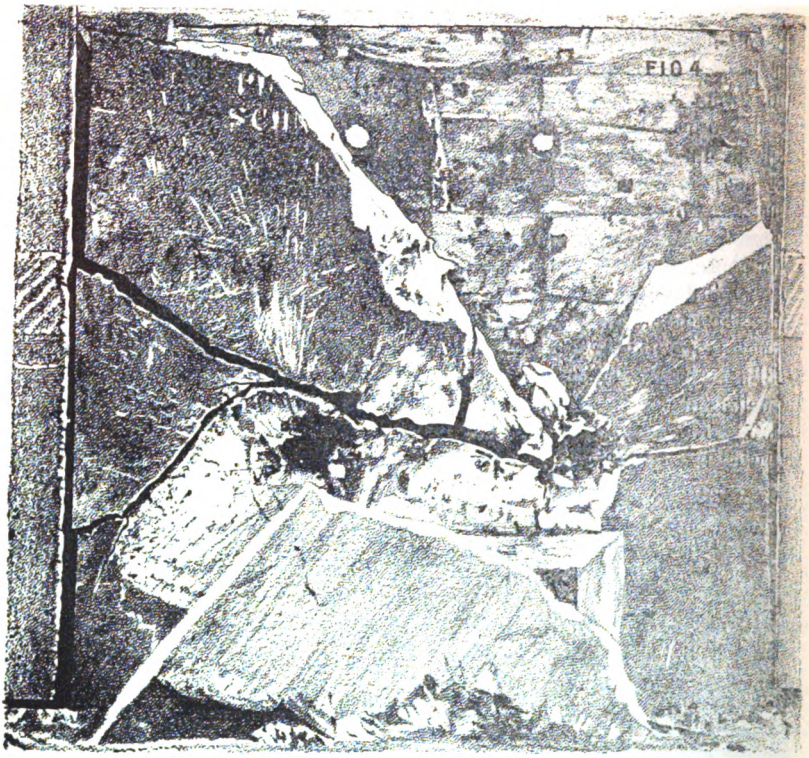

FIG. 5.

be only equal to 17·8 ins. of iron, or about a 13·36-in. compound or steel plate. Suppose that the plate only weighed about 21 tons, the shock would not be greater than that on the Wilson compound steel experimental plate above-mentioned. The plate, however, probably weighed 27 tons, and if so, the shock per ton was but small. Every plate tried for the *Terrible* appears to have cracked through on the first blow, and thus would have been rejected if tried at Portsmouth. An 18-in. compound plate at Shoeburyness received a blow nearly corresponding to this on July 21st, 1880, (*vide* p. 286, Vol. XIV.) with insignificant effect from the 12·5-in. gun, with a chilled-iron projectile striking with a velocity of 1504 ft., the weight being 828 lb., and an energy per ton of 541 foot-tons.

Both Brown and Cammell's plates, when below 12 ins. thick, have borne an amount of work out of all comparison with this.[1] An 11-in. plate of Brown's, 10 ft. by 5½ ft. in area, at Shoeburyness received three blows from 9-in. chilled shot, one blow from a 9-inch steel projectile, and two blows from 12·5-in. (38-ton gun) steel projectiles weighing 840 lb. and 845 lb. with 1425 ft. and 1413 ft. velocity and 19·8 in. perforation, and about 11,820 foot-tons and 11,690 foot-tons. In all 38,471 foot-tons, or, taking the plate at 11 tons weight, 3497·4 foot-tons per ton of plate. Discs of metal were nearly or quite separated by the two last blows; but the backing was sufficient to stop them, and the plate held fairly together except one corner. This, of course, was a result beyond all comparison with what we have given above, for here an 11-in. compound plate held together and stopped blows which were probably as severe as those which broke up the French steel 19·5-in. *Terrible* plate, the respective energies are 11,820 and 11,930 foot-tons, but the English plate was attacked by cast steel and the French one only by chilled-iron projectiles, so that the former probably delivered the more energy into the plate before breaking up. It is fair to remember, however, that only a limited number of results from Gâvre come to us, and that these are doubtless worse than would now be obtained; although, as we have nearly the whole of the samples tested for the *Terrible*, they represent fairly the quality of the supply at that time. It is quite possible that some very excellent samples might now be produced from Gâvre, although hardly likely to be better than one which is to be noticed presently. The Schneider plate tested at Spezia in 1882 is enormously better than the *Terrible* samples. This plate had no visible crack on the first round, and it received in four blows 3882·2 foot-tons per ton of plate. It was, however, by that time broken up, the upper portion of the plate hanging loosely out of its place, and large fragments detached altogether (*vide* Fig. 19, p. 406, Vol. XIV.).

The 1884 Schneider plate allowed the shot to pass clean through it, so that, excellent as the plate appeared, it is impossible to argue definitely on it. To do Schneider full justice, then, take the case specially selected and put forward by Lieutenant Jacques, as the crowning success in the shape of steel plates fired at at Gâvre, viz.,

[1] *Vide* p. 294, Vol. XIV.

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that tested for the *Admiral Baudin*, on March 7th, 1884. (Fig. 6). Here three rounds were fired at a plate 12 ft. 9 ins. long, 8 ft. 2 ins. wide, and from 18 ins. to 20 ins. thick, weighing 35·45 tons. The 32cm (12·6-in.) gun attacked it with three chilled-iron projectiles, the two first striking it with velocities of 1518, 1518 ft., and on places 18·5 ins. thick, and the third one with 1593 ft., on a place 19·8 ins. thick. The

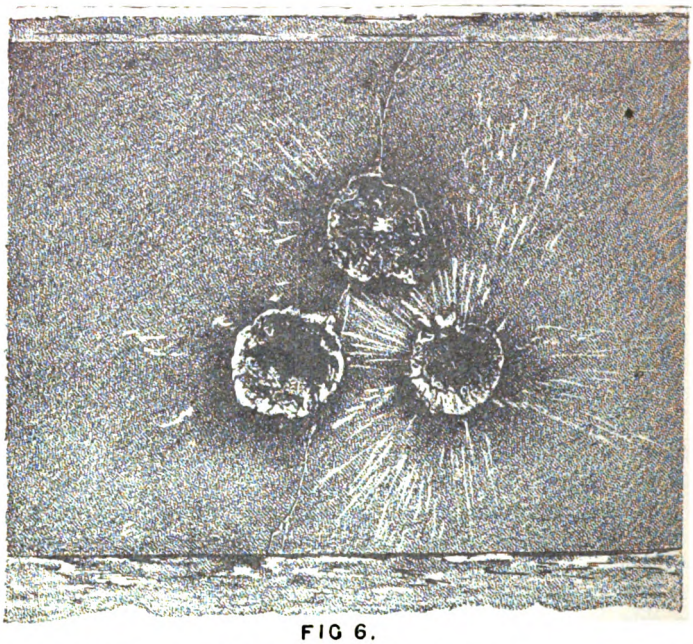

FIG 6.

last gives a perforation of 19·44 ins. of iron, or 14·58 ins. of compound on steel.[1] The plate looks well in the drawing, but the test is not a severe one; chilled projectiles were employed, the heaviest blow being only about 378 foot-tons per ton of plate, and the whole three only making up 1064 foot-tons per ton of plate. The shield, moreover, is apparently broken entirely through into two pieces, and only preserves its fine appearance from being well bolted up; and this may lead on to the great distinguishing characteristic of solid steel as compared with compound armour when both behave fairly well. This, which has been before stated, appears to be as follows:—Steel armour stands up rigidly, breaking up in through cracks, but if well bolted remains in its place.

Effect of bolts.

How successfully bolts may be employed may be seen by an inspection of the back of the steel plate given in Fig. 5, p. 320, in which it may be observed that the cracks seldom run through the bolts. With this experience it is no wonder that Schneider insisted on having twenty bolts in the 1882 trial, when Cammell and Brown competed with only six bolts each. Schneider was undoubtedly

[1] E = 13390 foot-tons.

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right, Cammell and Brown should have had the same; but their encouraging experience with smaller plates and the limited firing trial of 18-in. plates rendered them more liable to be caught in this way than Schneider. Now to consider another point—namely, the element of certainty in behaviour. The variation in the quality of steel is probably always greater than in iron; but there is another shape in which the caprice of steel is shown—namely, in spontaneous fracture.

The extraordinary statement is made on authority which ought to be good, that out of the steel plates supplied for the *Terrible*—about ninety in number—eighteen actually cracked spontaneously. Of these, fourteen broke at Creusôt, either after tempering or after annealing; one cracked at the time of dispatch to the port, and three broke while in the port of Brest; but before they were placed on the vessel. If this is true, the *Terrible* is clad in very capricious armour, armour which would break and crack wholesale under fire, and possibly would develop cracks in severe changes of temperature. If, however, it is bolted on the ship as well as Messrs. Schneider generally bolt it, it would protect the ship well under heavy blows in spite of its cracking. On the other hand, the continued fire of comparatively light guns ought to produce an effect on it disproportionate to their power. It must be admitted, that a steel 18·9-in. plate used for proof of 5·9-in. projectiles at Spezia recently received a great many blows without a great loss in resisting power. It cracked through in broad lines, but if well bolted it would resist any fire of 6-in. guns likely to fall on it. Still, 5·9-in. guns are very insignificant pieces to attack an 18·9-in. plate. After considering all the facts above discussed, what are we to conclude as to the relative positions of steel and steel-faced armour?

Solid steel and compound plates compared.

In spite of a natural preference for English manufacture, it will be seen that in the earlier pages devoted to this subject, written before the above information had been obtained, it had been contemplated that steel-faced armour would be displaced by steel—steel on the compound principle perhaps, but steel in some form, sooner or later. Not so much on account of actual results, as because of the great possibilities of steel generally. Just as steel had displaced iron in boiler plates, guns, and projectiles, so it seemed likely to do in armour.

Confidence was not expressed in steel armour, however, in an unqualified way, because, although there had been disappointment in some larger compound plates, and better steel plates had been made on a larger scale, compound plates of 12-in. or below had repeatedly beat steel in competitions. Now facts have been brought to light that raise the question whether steel-faced iron plates may not finally prove the best, and certainly forbid admitting that steel has shown itself superior up to the present time.

The facts referred to are:—(1) The cracking of our own steel experimental plates, made with soft steel backing, and still more the cracking of iron backing when it possessed the very qualities supposed desirable—that is, high tenacity coupled with great elongation. (2.) The records of the *Terrible* plates, and the conviction that, even in the selected specimen of the *Baudin* sample, the plate is broken entirely asunder by comparatively light blows, and those with chilled-

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iron shot, which have long since, even in England, been pronounced inefficient for the attack of steel or steel-faced armour. If it be denied that the plates are cracked through, why is not the back exhibited? And if the plates will bear really severe tests well, why are guns of such disproportionate power used to prove them, and those with chilled projectiles? (3.) The strange account of the spontaneous cracking of steel plates. (4.) The last victory of the compound plate over the steel at Pola, showing that on the scale on which compound plates have been continually tested and best worked, steel has never been able to compete with them. These facts ought to be met with *actual* facts and figures before we are justified in passing them over.

Happily we are not greatly concerned as a country which kind of armour is eventually adopted. Cammell and Brown have the plant for making steel plates to-morrow, if desired.

At Brown's a gigantic press is in course of erection, capable, it is thought, of turning out sounder steel plates than could be obtained by hammering. There is little prospect, however, of steel displacing steel-faced plates, especially as a Brown experimental steel-faced plate has recently (April, 1887) stopped a Holtzer shell with remarkable success.

It would be right to try steel in this country. The question of superiority is quite an open one yet. The prospects of success for solid steel would, under present circumstances, much depend on the power to give it a harder face than has hitherto been given to it, coupled with a softer back. It must also be shown to be free from the liability to spontaneous fracture or brittleness from atmospheric conditions. There is something pitiful in the thermometer being consulted, and in the circumstance of a steel plate having to be warmed before firing at it, as it is stated took place at Amager in the winter of 1883-84. Should the Admiralty change their minds, and conclude that the fact of plates breaking through does not signify so long as they are held in their place by bolts, the prospects of steel in this country will be much improved; but compound steel ought in the long run to have a better chance than solid steel. So long as we expect to take down our plates intact and look at their backs after impact; and further, if we test them under oblique fire where a hard surface tells most, and if we back them well, probably solid steel is a long way from competing successfully with steel-faced plates.

At some time steel may probably become more trustworthy, it may possibly, eventually, attain the property of elongating instead of cracking under the blows of shot; but this is almost saying what we all know, that steel is daily made more and more like wrought-iron in a pure form. With this a hard face does not seem attainable. At present those who employ armour on their ships must take a practical view of the matter and choose between the properties possessed by the two kinds as they are now presented to us, or are likely to be presented for some time to come. *Compound armour*, with *a steel face and soft iron back*, is likely to hold its own as the safest and most reliable plate for ships under present circumstances, while for facing granite or other hard material it has shown extraordinary powers.

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The following is a list of the naval Powers employing steel and compound armour at the present time:—England, compound; Argentine Republic, compound; America, compound, but most likely steel will be tried; Austria, compound; Brazil, compound; China, compound; Denmark, compound; France, compound and steel; Germany, compound; Holland, compound; Italy, *Italia* only compound, the other vessels steel; Russia, compound; Spain, steel recently ordered for one ship, compound talked of for another; Sweden, compound and steel. Naval powers employing steel-faced and steel armour.

The makers are for *steel:* Schneider, at Creusôt. For *compound* (on Ellis' patent) Brown, at Sheffield: (and on Wilson's patent), Cammell, at Sheffield; Marrel, at Rive de Gier, Loire; La Compagnie Anonyme des Forges, at Paris; La Compagnie des Hauts Fourneaux, St. Chamond; the Dillingen Works, in Germany; and Tjora Iron-works, Kolpino, St. Petersburg.

Projectiles for the attack of armour have been made of ordinary cast-iron, wrought-iron, chilled cast-iron, and steel, and compound shot of chilled cast-iron in conjunction with steel have been used experimentally. Projectiles.

Ordinary cast-iron soon proved ineffective for thick armour. It may, however, be employed in common shell against thin armour. Common shell have perforated unbacked iron of a thickness equal to half the diameter of the shell (*vide* pp. 129 and 130, Vol. XIV.). One common 9-inch shell from the *Shah* perforated the side of the *Huascar* (4-inch plate) and burst in the backing. Wrought-iron shot hold together but spread out against the plate, it is scarcely likely that they could be used with advantage even for racking purposes (*vide* pp. 435 and 436, Vol. XIII.). Steel shells with heads screwed on were proposed by Major-General Alderson in 1865 and acted fairly well. Chilled cast-iron were brought forward by the late Sir W. Palliser in 1863[1] and have been made in the Royal Arsenal and other factories almost without interruption since. They are made from special mixtures of iron, Ridsdale, Cwmbran, pig and broken projectiles have been principally used, doctored at times with "*ilmenite.*" The projectiles are cast point down in moulds of iron for the heads and sand for the bodies. By means of the conducting power of the metal the point and head become sufficiently chilled to cause the iron to be white, while in the body the carbon separates to a certain extent.[2] Chilled metal is specially hard and dense and has great crushing strength, but it is brittle, the body is intended to have more tenacity. The hardness and crushing strength of chilled metal remain almost unrivalled to the present time. The points never flatten, and the metal remains remarkably cool after impact. The best Ordinary cast-iron. Palliser chilled iron projectiles.

[1] *Vide* p. 426, Vol. XIII. Lieut.-Colonel Barlow, R.A., contributed a paper on "The manufacture of chilled and other Projectiles in the Royal Laboratory," in R.A.I. Proceedings, Vol. IX., No. 3, 1875, to which reference may be made for details.

[2] When in the Royal Laboratory, about 1866, the author, in a very limited imperfect way, compared the conditions of the same metal when chilled and cast in sand by taking specific gravities and acting on them with nitric acid. The specific gravity appeared to be increased about 3½ per cent. by chilling.

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steel has only recently been made to stand as well up to its work, at the point, where compression only is concerned. Chilled projectiles fracture very easily if exposed to oblique blows in store, and are liable to crack from molecular action. In short the metal is in a constrained unnatural condition, but its excellence for punching work, especially in soft armour, has caused it to be tried in points of shot which are made of steel or strengthened by steel.[1] The peculiar weakness of chilled metal was remarkably well illustrated in its pulverization in air space targets.[2] Chilled shot depend on getting their heads into the armour before the full shock comes on them, and are apt to break up badly against the hardest kinds of plates, that is against chilled-iron shields, and against solid steel. Against steel-faced plates chilled-iron in this country has occasionally produced better results than could have been anticipated.[3] Nevertheless, seeing that armour is likely to become increasingly hard and that chilled-iron and solid steel are much used abroad, the supersession of chilled-iron[4] by steel has been obviously inevitable; the manufacture of chilled projectiles was discontinued in the Royal Laboratory in October, 1886, though since resorted to, to meet immediate demands. For sections showing projectiles chilled in different ways *vide* p. 275, Vol. XIV. In judging of the harshness of fracture, novices are specially warned against the fracture shown by pieces chipped off near the surface, which often exhibits a beautifully fine silky texture, while a deep normal fracture is much coarser. Steel has been sometimes combined by mixing, by melting up with iron in chilled-shot, both by Krupp[5] and in the Royal Laboratory, as well as in Wilson's shot, where the point is cast of chilled-iron and the body of steel.

Supersession of chilled-iron by steel.

Steel projectiles have been made of innumerable kinds both forged and cast. Alderson's, mentioned above, were some of the first tried. As it is impossible at present to specify any distinct steel shot or shell as service projectiles, it is better to say very little generally and refer to each steel projectile under the head of particular experiments. Whitworth's forged steel projectiles at first performed the most remarkable feats in England and Italy. They invariably have a small hollow up the axis and a point screwed into the head. They can be fired through great thicknesses of wrought-iron repeatedly, almost without deterioration, even when the heads are undesirably blunt. They cannot be burst by powder. Cammell's have produced good cast-steel projectiles which have held together under impact at very high velocities; a Hadfield cast-steel projectile passed through a steel-faced plate in 1884 without breaking up;[6] but more experience is needed to develop cast-steel shot in this country, especially for the

Steel projectiles.

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1 As in Wilson's and Palliser's experimental projectiles.

2 *Vide* pp. 431, Vol. XIII., and 128, Vol. XIV.

3 *Vide* p. 437, Vol. XIV. Many unpublished experiments also bear this out.

4 For comparative effects of chilled and steel projectiles against chilled-iron shields, *vide* pp. 283, 630, and 636, Vol. XIV.

5 Fragments of such projectiles at Meppen in 1879, puzzled some visitors including the author.

6 *Vide* p. 429, Vol. XIV. The plate was an injured one.

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larger natures of guns. Krupp's steel projectiles have stood up and behaved generally in the same manner as Whitworth's some years ago, and great progress has been made in the development of steel projectiles on the Continent, while England has stood still. In a competitive trial of 6-inch steel projectiles at Spezia in 1886, an 18 or 19-inch steel plate was attacked by direct fire. The whole of Krupp's projectiles entered to a depth approaching nine inches and rebounded without serious deformation. Holtzer claimed that the best result was obtained by one of his projectiles. The Italian officers considered Krupp had succeeded best, probably because Holtzer's shells, which varied in quality and measure of success, were considered to be in an experimental stage, while Krupp had achieved a fixed standard of excellence. In the summer of 1886, Firminy and Holtzer's 12-inch steel shells passed without fracture through 16-inch compound plates at Shoeburyness. The Firminy shell struck a weak place in a plate behind the target and remained unbroken. The Holtzer shell struck a sound place and then broke. The best forged steel projectiles appear to be made of steel, sufficiently soft to allow of finishing with a cutting tool in a lathe. They have slight projecting bands, at base and shoulder, to facilitate bringing the shot to exact dimensions at the larger part. The front part of the projectile is then hardened and tempered, and the bands of the shot ground to exact dimension. An excellent lot of Holtzer projectiles were passed into the Service in March, 1887.

French steel shells generally contain from 1 to 2 per cent of chromium. Fragments of point and base of Krupp's shell fired against Grüson's shield at Spezia in 1886, brought to England and tested, contained respectively 0·891 and 0·864 per cent. of carbon but no chromium.

CHAPTER XIV.

Armoured Structures.—Ships.

It would be unwise to attempt to deal with this subject, further than to give a few facts and such general rules as may be useful to those who only are interested in the question, so far as it concerns the action of guns and armour. An armour-clad ship is a sufficiently important machine, and the number existing in the world is sufficiently limited for each ship to have an individual character and reputation, which is known and recorded in all centres of information on naval matters.[1] At the Admiralty, for example, there exists a quantity of information, obtained in many cases confidentially, but which it is to be presumed would be utilized in time of war. It can

[1] For descriptions of ships *vide* Brassey's "Naval Annual," "King's War Ships and Navies of the World," and "Kriegsschiffbauten Kronenfels." The author is much indebted to Sir Nathaniel Barnaby, the late Director of Naval Construction, for answering all questions raised by him very fully.

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hardly be doubted that in case of war breaking out with any nation, a description of each of the enemy's ships, with a cut showing all her characteristic features, would be issued to our vessels and coast batteries. Even under these circumstances, a few notes as to the classification of ships might be useful to those who have to engage with ships without having made them their study. For practical purposes, dealing only with their armour, armour-clad ships may be divided into the following classes:—(1), *Broadside, old-fashioned, with guns distributed.* (2), *Masted sea-going modern types, including barbette, central battery, and turreted masted vessels, as well as protected ships.*[1] (3), *Mastless turret.* It will be found that vessels will not range themselves exactly under these classes, wide as they are.

Old-fashioned broadside ships.

Class (1). *Broadside, old-fashioned ships, with guns distributed.* In this class the armour is thin, running from about four and a-half to six inches. It extends however in some cases nearly entirely over the side of the ship. Thus, weak as such ships are, they can in hardly any place be attacked by shrapnel fire or that of machine guns, or even quick-firing 6-pounder guns. Their own guns are distributed along the greater part of the side of each ship. The *Minotaur*, or the *Provence* or (French) *Heroine*, fully represent this class. It is probable that common shell from 12-inch guns might be used against them,[2] at the same time it is difficult to speak with confidence, common shell having been only tried against unbacked plates, and against the *Huascar*, when a 9-inch shell got through her 4-inch plates and burst in the backing. Palliser shell filled, acted with terrible effect against the *Huascar* turrets, whose armour was about the same thickness as most of this class (viz., 4½ inches of iron backed by 10 inches of teak). As the armour of this class of ship is wrought-iron it must be perforated, and comes under the rules for that class of attack, that is, the effect depends on work per inch circumference of shot. The fire of guns able only to partially penetrate the sides is useless, however long continued. Such guns are only available for what has been termed the secondary attack (masts, &c.) Ships of this class however might be perforated by almost any modern rifled gun. Even the 7-inch old type Woolwich gun would perforate most of them directly (the *Minotaur* up to over 1200 yards range). Being deficient of deck armour they are specially open to attack by plunging fire or vertical fire, but as their guns cannot train through a large angle these vessels would engage nearly broadside on, a position favourable to the attack of their sides rather than their decks.

Modern masted sea-going ships.

Class (2) *Masted sea-going modern types.* The characteristic of the armoured protection being that it is very thick in important places, while many parts are left without any armour. Generally speaking, the heavy guns are concentrated either in a citadel at the centre of

[1] Sir N. Barnaby in his *Naval Review* of 1886 divides ships into—(1) Armoured with armoured gun positions; (2) Protected with unarmoured gun positions; (3) Unprotected.

[2] *Vide* p. 129, 130, 132, Vol. XIV. The disc struck out by this class of projectile would be impeded by backing to a great extent, and failing experiments it is difficult to speak with any confidence.

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the ship or in barbette towers, or turrets, but in some instances a broadside battery of medium guns exists without any armour. The *Admiral Duperré*, for example, has 14–5½-inch guns (*vide* Fig. 1) without armour. Our own *Shannon*, *Nelson* (*vide* Fig. 2), and *Northampton* have their 9-inch broadside batteries unprotected. These latter do not profess to take rank as fully armoured vessels, being termed "pro-

FIG. 1.

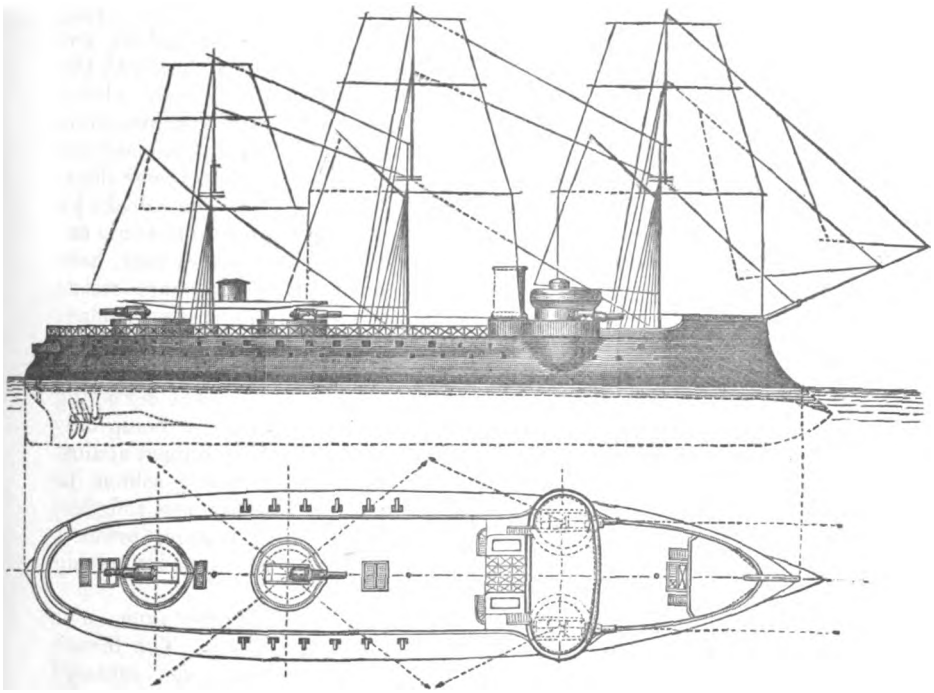
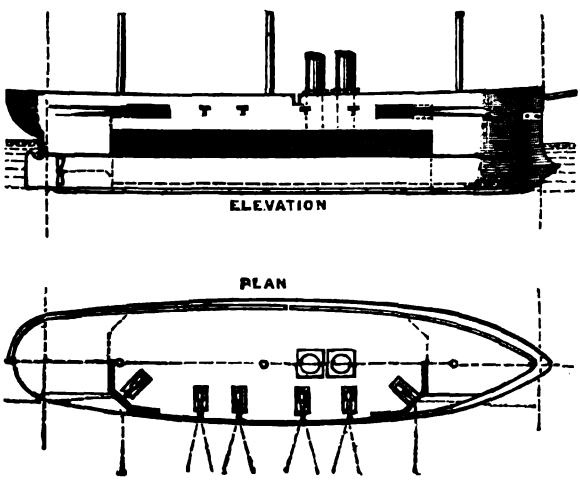


FIG. 2.



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tected ships" which are constructed to engage "head on" with their most powerful guns, in which position they are protected by armour both in front of the 10-inch guns and across the bows of the vessel in a bulkhead. It does not seem worth while distinguishing this class, however, seeing that both in the French and Italian navies some of the most powerful ships have guns similiarly exposed. It is only possible, then, to direct attention to a few features that may be found, and to depend on individual descriptions of each ship for further information. Speaking generally, the French vessels have the peculiarity of mounting their guns very high above the water and firing them *en barbette*, not on the disappearing system carried out in our *Temeraire*, but with the men exposed above the *barbette* armour. There is a steel plated structure overhead which protects them from the fire of machine guns in the tops of vessels, but the exposure of the men to mitrailleuse and shrapnel fire is a remarkable feature in the French *barbette* tower ships.

These ships would seldom suffer from the attack of their decks by guns as they could very seldom be struck at a descending angle exceeding 10°, and British ships, and probably many foreign ones, have deck plates to resist at 10° the same fire as the side armour resists direct. At anchor their decks might be assailed in a dangerous manner by mortar fire, and often great injury might be done in the structure above the armoured deck. Their unarmoured parts might be attacked by common and shrapnel shells. Common shell require a quicker acting fuze than the Pettman G.S. to burst violently. Shrapnel being only required to break up, may be fired without any fuze,[1] as impact against the thin iron side of the ship breaks them up. It would seldom be possible to strike a ship below her armour belts even in the roughest weather in which she is likely to fight. A ship's conning tower is an obvious object for attack. There is little to be done by cutting down her funnel.[2]

If the primary attack of the side armour is undertaken, it is important to know if it is iron, steel-faced, or steel. The former suffers only by perforation; and *partial penetration*, even repeated many times, produces little effect in action beyond starting bolts and producing langridge. Steel-faced and steel plates suffer probably in proportion to the total energy of the shot striking them. Even the best steel *filled* shell are seldom useful against thick armour; but this is more fully discussed under the head of Class 3. Fig. 3, p. 331, shows the Chilian vessel the *Almirante Cochrane*, well known from her share in disabling the *Huascar* (*see* p. 343); she is armoured from bows to stern at her water-line, her six heavy guns are in her central battery,

[1] *Vide* p. 126, Vol. XIV.

[2] The *funnel* may appear to be a tempting mark for light guns, but little can be done by striking it above deck, as the following consideration may show:—The boilers are placed low down in the hull, and the funnels must be measured from the fire grates. Suppose the total length of funnel to be 50 ft., and that it is cut down to 30 ft. The diminished power of generating steam will be to the original power in the proportion of $\sqrt{33}$ to $\sqrt{50}$, that is 5·5 to 7·1. The ratio of the speed is, nearly proportional to the cube root of the generating power, that is, as $\sqrt[3]{5·5}$ to $\sqrt[3]{7·1}$, or about 1·768 to 1·920. In other words, the vessel would only lose 1 knot in 12 by such an injury—though inconvenience might doubtless be felt from the escape of smoke on deck.

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terminating at her main-mast. She is a fairly typical ship of her date (1874), designed by Sir E. Reed.

Class (3) includes all *mastless*[1] *turret* ships and *mastless barbette* ships whether sea-going or coast defenders. Generally they are more heavily clad, both on their sides and deck, and carry heavier guns, but fewer of them than any other class of vessel. The *Italia* and *Lepanto* (*vide* Fig. 4 p. 332, and Fig. 5 p. 333) which have no side plates, and depend entirely

Mastless ships.

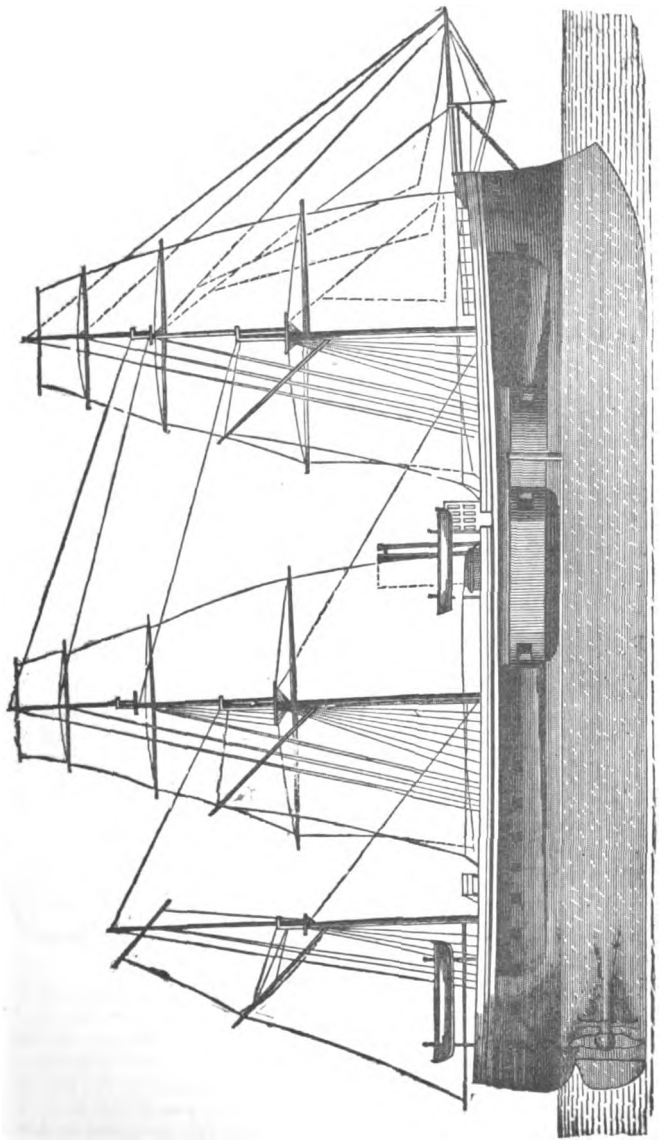

Fig. 3.

[1] That is carrying only signal masts.

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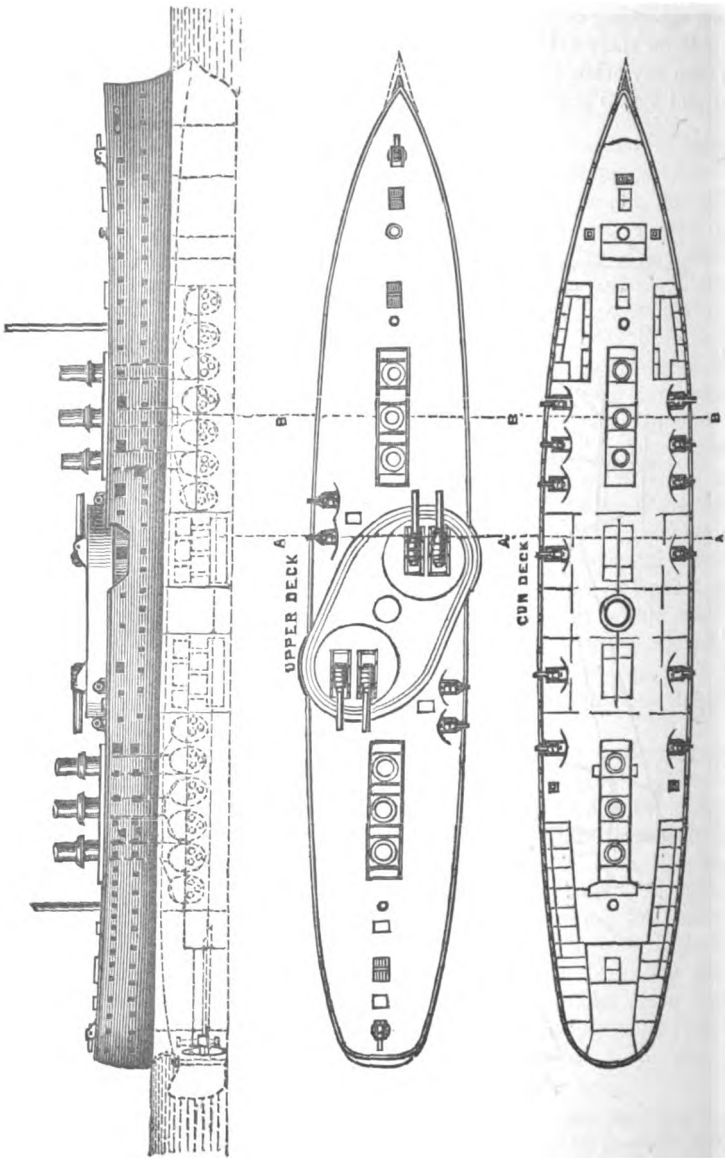

FIG. 4.

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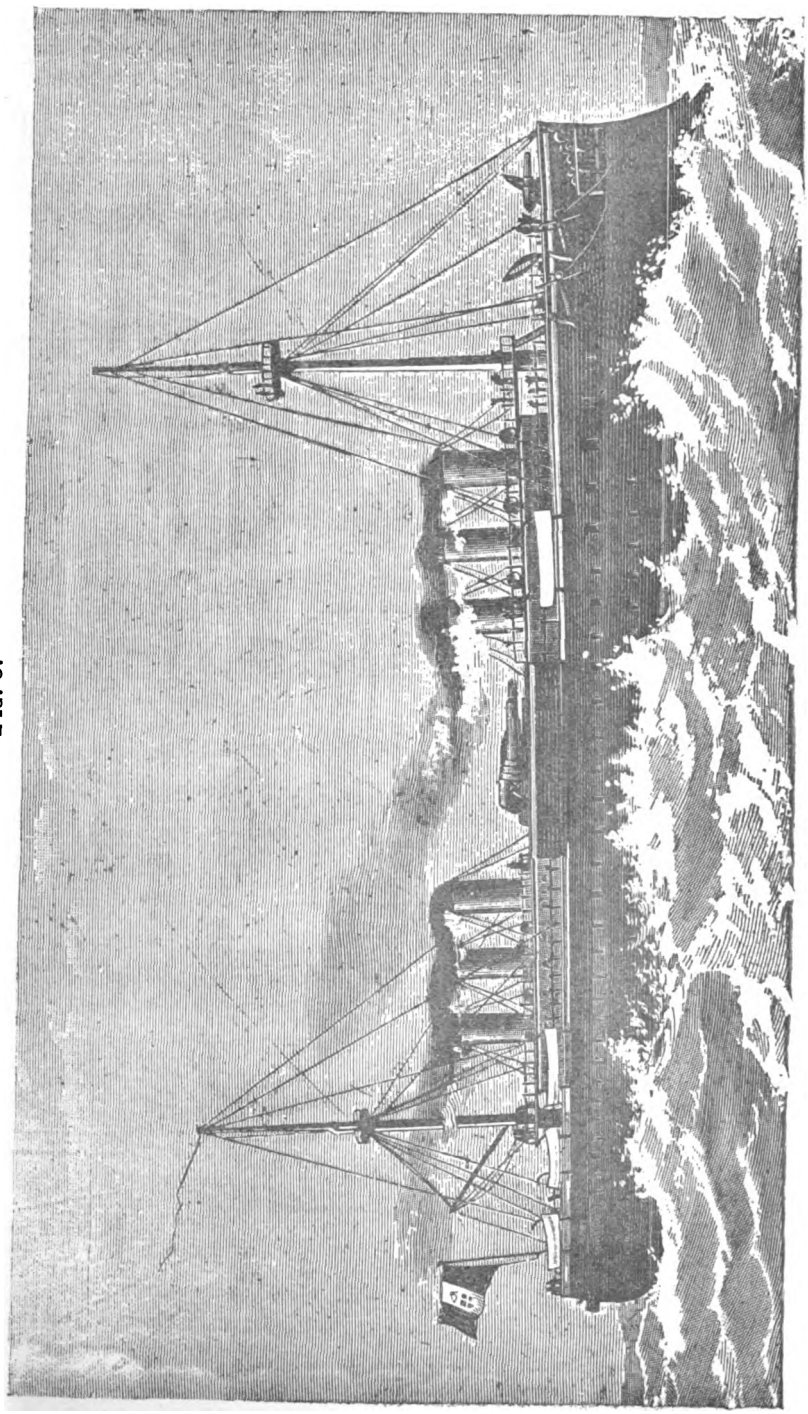

FIG. 5.

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FIGS. 5 and 6.

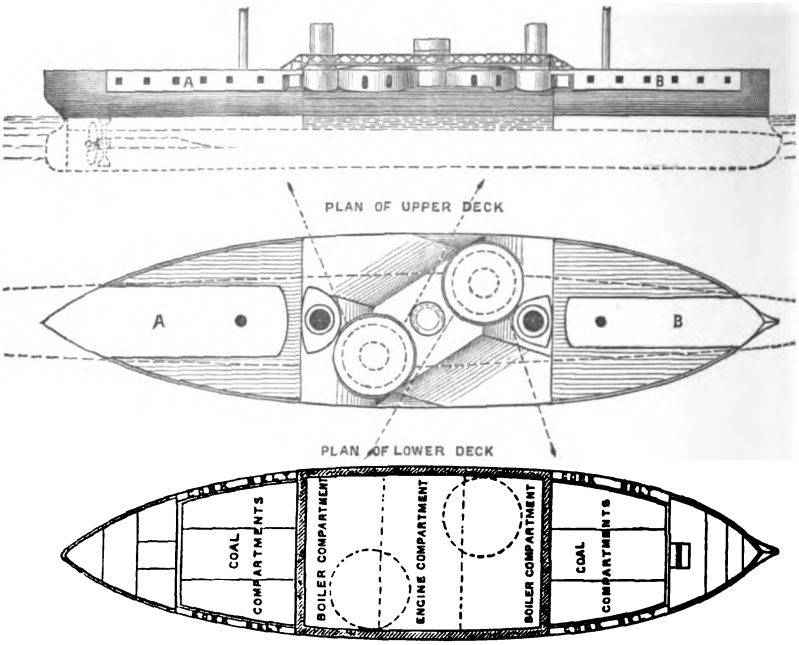
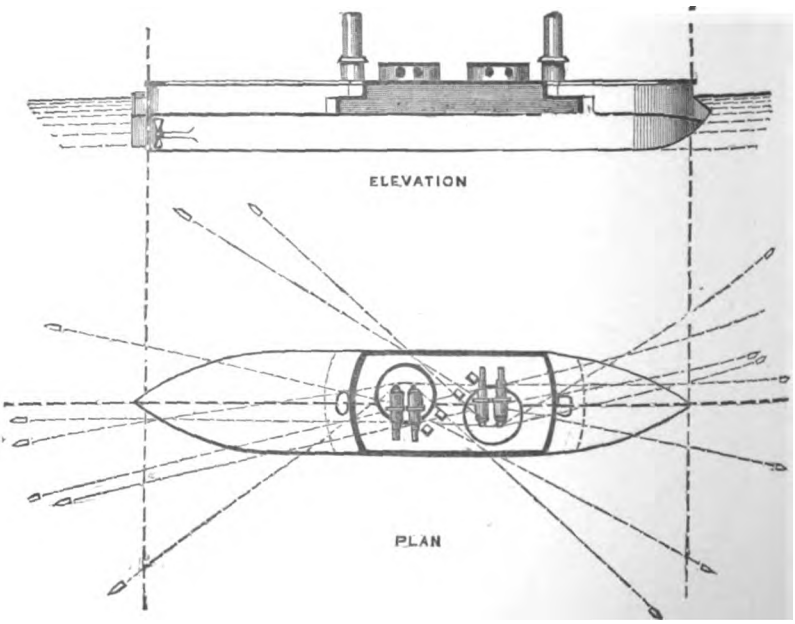


FIG. 7.



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on *barbette* armour, and horizontal armour, are remarkable exceptions. The *Inflexible* (*vide* Figs. 5 and 6) *Duilio* (*vide* Fig. 7, p. 334) *Dandolo, Ajax, Agamemnon, Colossus,* and *Edinburgh,* are instances of citadel turret ships, and the *Admiral* class, (*vide Benbow,* Fig. 8,) of *barbette* citadel ships with unarmoured ends. The secondary attack would probably be adopted against such heavily clad vessels. On the other hand, such ships as the *Glatton, Dreadnought, Thunderer* (*vide* Fig. 9) and *Devastation,* are hardly open to any secondary attack. With regard to the

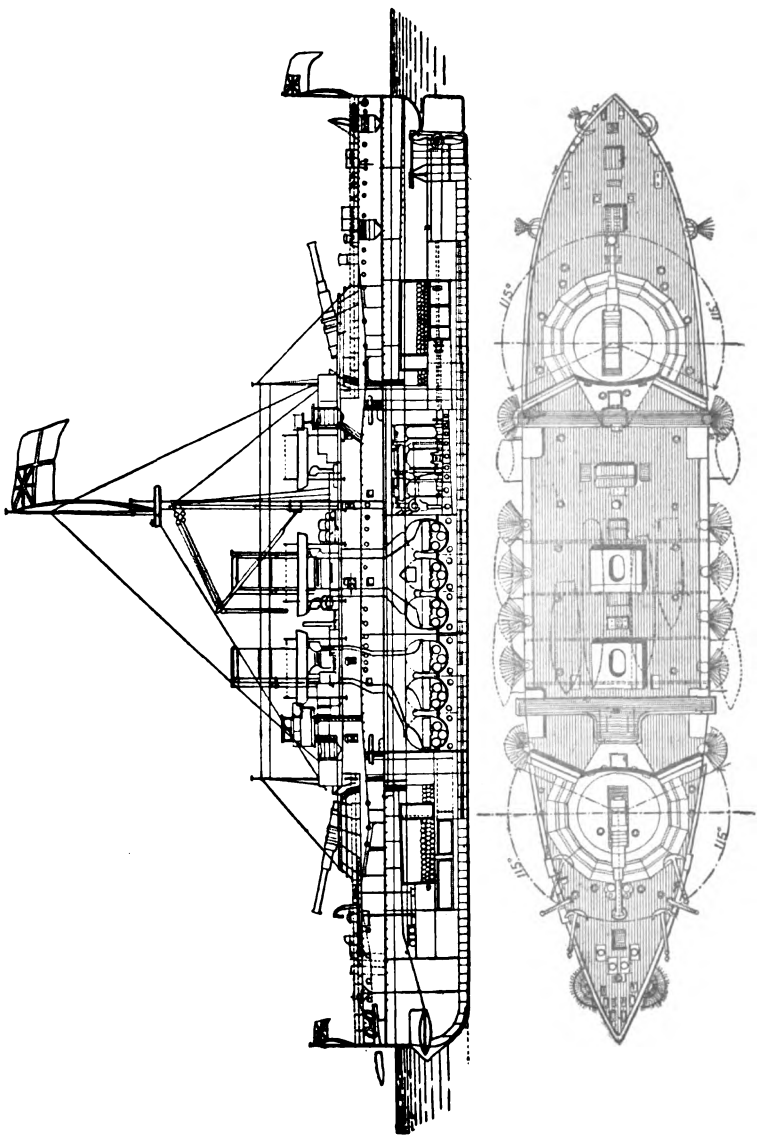

Fig. 8.

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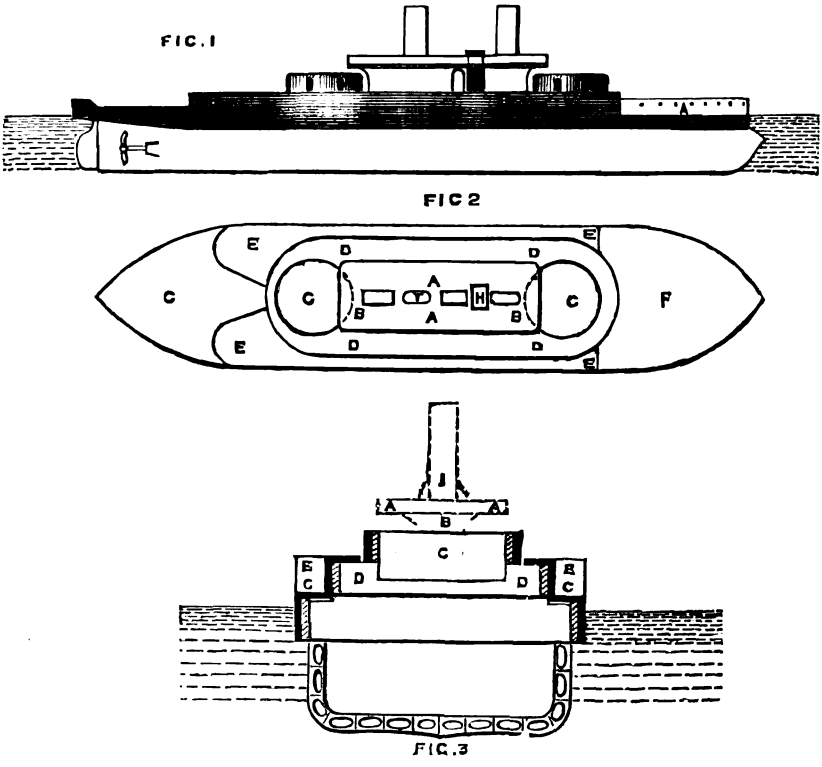
FIG. 9.



primary attack of the side armour, it is very important to know whether the ship is plated with iron, steel, or steel-faced armour. If iron it is useless to attack with projectiles that have not at least 1000 feet striking velocity for each calibre in the thickness of the armour. Thus a 12-inch gun requires at least 1000 feet velocity for each 12 inches, 1500 for 18 inches, and 2000 for 24 inches. As the ship is seldom exposed to a perfectly direct blow, the chance of heavy armour being perforated is small, and it would be as a rule useless to fire steel filled shells, and much more chilled-iron filled shells at thick armour, oblique impact almost always breaking shells up. If the armour is steel-faced or steel, the chance of perforation by a single blow is small in the most heavily plated ships, but continued fire may break up the armour. Guns which are no match for the armour, and would be useless against it if it were wrought-iron, may assist in breaking up hard armour in long continued fire. Altogether the primary attack of the side armour of heavily plated ships, unless made by guns of power far out-matching the armour when it is steel-faced or steel, can only be expected to be successful if the ship is exposed a long time to it. Wrought-iron is more liable to perforation, but bears the continued attack of guns that cannot perforate it specially well. The nature of the armour might influence the choice

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of guns employed in attack. This is most obvious if the forts as well as ships be taken into consideration. At the present time any foreign fleet lying off a foreign armoured fort, would furnish an example of the two kinds of armour, for the older ships would as certainly be clad in iron, as the forts would be covered with Grüson's chilled-iron armour. Wrought-iron must be perforated. Chilled-iron must be fractured. The former is effected by shot in proportion to their powers of perforation, the latter probably in proportion to their energy. What is especially liable to mislead, is the fact that gun's powers are generally estimated according to perforation. Speaking generally, the new type guns would display their powers best against ships, for though total energy and racking power has been increased in these guns, it has not been at all in proportion to the increase in power of perforation, because the small calibre assists perforation, but does not affect the question of total energy and total smashing blow.

Thus the older-fashioned guns might do better against forts than might be expected, while any smaller new-type guns would only display the full powers, with which they are generally credited, against ships or other structures covered with armour sufficiently soft to admit of perforation.

It appears to be generally recognised now that if ships are brought to anchor, they are subject to attack of their decks by mortar fire.[1]

It is hardly necessary here to discuss the ships that depend on their small size and powers of attack, and in which armour is dispensed with. They are sometimes protected from machine gun fire by steel shutters, as in the larger cruisers built at Elswick for China. Coal is utilized as far as possible, and the vital parts of the ship are kept below the water line. (For coal, *vide* p. 339).

Polyphemus

The *Polyphemus* can hardly be called an armoured vessel in the usual sense of the term, but she is covered with curved steel deck armour. The general figure of her structure in an incomplete state is shown in Figs. 10 and 11, p. 338. The entire "turtle back," to five feet below the water line, is covered with a Whitworth inch steel plate (45 tons tenacity). From 2½ feet below the water line the turtle back is further protected by Whitworth steel scales (*vide* Fig. 12) ten inches square and one inch thick, held by screws, as shown in figure (tenacity 65 tons); besides this plating she is constructed of double ½-inch ship-building steel of about 26 tons tenacity. The figures of the *Polyphemus* are not correct in all details, and are only intended to show the general form and character of the vessel.

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[1] *Vide* Meppen experiments, 1879, p. 280, Vol. XIV. Rifled howitzers have been supplied to our coaling stations.

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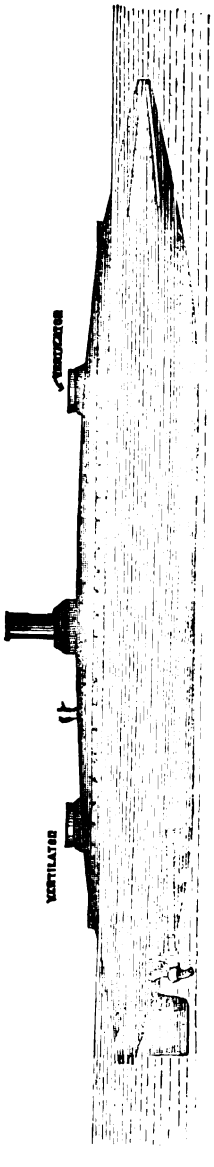


FIG. 10.

FIG. 11.

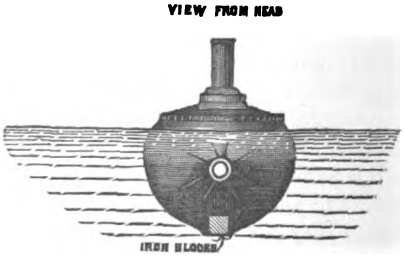
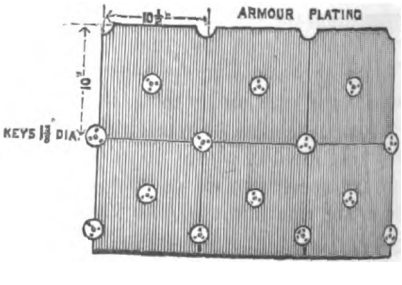


FIG. 12.



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CHAPTER XV.

Coal Protection.

In 1880, some experiments[1] were conducted by the Committee on Ordnance, of which the *late* General Gordon, C.B., was President, with a view to ascertaining the effect of shells on coal, in order to obtain data as to the defence of unarmoured ships, such as merchant vessels, and also as to the substitution of coal resistance for that of side armour in battle ships.

A coal target 60 ft. thick was used in order to represent the case of a ship filled with coal from side to side.

The 6-inch R.B.L. gun was employed at 100 yards range at coal without any fortification plates.

3 Palliser chilled shells filled with sand, fired with 32 lb. charges, penetrated from 16 to 18 feet, 2 broke up on impact.

1 common shell filled and fuzed, firing charge 34 lb. P., burst after penetrating 13 feet, striking velocity about 1850 feet.

2 common shell filled and fuzed, firing charge 25 lb. P., and one double shell, similarly fired, burst after penetrating about 9 feet.

Fortification plates $\frac{3}{8}$*-in. thick,* were inserted in the coal 3, 6, 9 and 12 feet from the front.

1 Palliser shell (weighted) firing charge 34 lbs. P., penetrated 3 plates, entering 12 feet into the coal and 11 inches into the ground, another, similarly fired, penetrated 4 plates and 17 feet of coal.

1 common shell filled and fuzed, fired with 25 lbs. P., burst at 6 feet penetration, passed through first plate, and blew a hole through second one.

1 double shell filled and fuzed, charge 25 lbs. P., burst at 8 feet, having passed through first and second plates, and made a hole in third plate.

1 double shell, similarly fired, burst at 3 feet, blowing hole in front plate, but not reaching second plate.

With fortification plates $1\frac{1}{2}$*-in. thick of mild steel,* 12 *feet from front,* no coal behind plates.

1 Palliser shell weighted, charge 34 lb. P., shell broke up, fragments stopped by plate.

1 Palliser shell filled with powder, charge 84 lbs.; shell apparently burst, fragments did not reach back plate.

Fortification plates, $1\frac{1}{2}$*-in. thick, mild steel, at* 5 *feet from front,* total depth of coal 15 feet.

1 Palliser shell (weighted) charge 34 lbs.; shell broke up. Plate broken, maximum penetration of fragments 10 feet.

1 Palliser shell (filled with powder) firing charge 34 lbs., plate broken; shell broke in two but powder charge not fired, total penetration 15 feet.

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[1] Not given in D. of A. Proceedings, but in a special report printed March 29, 1881.

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The 8-inch B. L. gun was fired at 100 *yards with* 90 *lbs. P. charge.*

Without fortification plates. 1 Palliser shell weighted, penetrated 26½ feet, 1 common shell (filled and fuzed) burst after penetrating 15 feet.

With ⅜-in. fortification plates. 1 Palliser shell, weighted, penetrated 4 plates and 18 feet of coal.

With plates 1½-in. thick, mild steel, at 12 feet from the front.

1 Palliser shell (filled with powder) burst just in front of 1½-in. plate, blowing hole through this plate and the ⅜-in. skin behind it.

With plates 1½-in. thick, of mild steel, 5 feet from the front.

1 Palliser shell (filled) burst, plate broken, maximum penetration of fragments 12 feet, skin plate at 15 feet driven back 20 inches.

It was concluded that a 6-*in. Palliser shell* (blind) with 34 lbs. firing charge, which, at 100 yards, had a striking velocity of 1850 feet, penetrated about 18 feet.

Fortification ⅜-in. plates placed vertically amongst the coal had little effect, their tendency is to deflect the shot.

A 1½-in. plate of mild steel was equivalent to 3 feet in coal.

Bursting charges of common and double shell had no incendiary and little or no disruptive effect. Palliser shell filled were less effective than weighted with sand.

The 6-in. gun at 100 yards should perforate a solid unbacked plate of wrought-iron 10½ inches thick. This may be taken as equivalent to 18 feet of coal.

The penetrative power of 8-inch Palliser into coal with striking 1930 f.s. was about 26½ feet.

Four ⅜-in. plates reduced the penetration by about 8 feet.

If, as in the case of the 6-inch gun, a 1½-in. mild steel plate is equivalent to 3 feet of coal, the penetration with 1-inch plate should be about 23 feet.

The common shell produced no incendiary effect.

The 8-in. projectile at 100 yards should perforate 13½ inches of iron, this should be equivalent to 26½ feet of coal.

Conclusions and recommendations.

20 feet of coal without plates is proof against 6-in. projectiles at short ranges, or 17 to 16 feet if a 1½-in. plate be inserted. 30 and 25 feet respectively would resist the 8-in. gun projectiles. With less coal more plates must be used. Steel projectiles would probably act better than Palliser projectiles, a large proportion of which broke up. It might be desirable to imitate the conditions of an actual ship and

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learn if the projectiles penetrate decks after deflection. Also the disruptive effect of large common shells and of steel shells charged with guncotton should be tried.

It may be seen from the above that, roughly speaking, 2 feet of coal is equivalent to 1 inch of iron.[1]

It is to be remembered generally that vessels depending on coal protection would be more vulnerable as their time at sea increases and their supply runs out.

CHAPTER XVI.

Results Produced in Action.

American experience

The first engagement that occurred between armour-clad vessels of any class was that of the *Merrimac* with the *Monitor*.[2] The *Merrimac's* armour was inclined at an angle of 30° with the horizontal; it consisted of narrow bars of railway iron in two thicknesses, making a total of 3 inches, laid on 20 inches of oak. The *Monitor* fired 11-inch smooth-bores, with 15 lb. charges. Lieut. Very observes—"As far as can be ascertained, no material damage was done, nor should it have been expected." Had the 30 lb. charge been used during the action . . . . which doubtless would have been the case if the government practice had not so carefully excluded it, the muzzle-energy of the projectile would have been 2730 foot-tons or more than double what it was, and, as was afterwards proved by experiment, both in the United States and in Europe, every fair blow planted by the *Monitor* in the action would have smashed a hole.

On April 7, 1863, the *New Ironsides*, carrying 4½ in. solid wrought-iron plates, backed by 21 inches of oak, took part in the general action with the Charleston forts. Captain Turner in his report says—"Forcing her way up the Channel, she received the fire of the enemy generally obliquely, excepting when she fell off one way or the other. One of these shots striking the forward facing of a port shutter, carried it away instantly . . . . the damage done to this ship, with the exception of the loss of a port shutter is not material. The distance at which she received the severest fire of the enemy is about 1000 yards."[3] It appears that the bolts were driven out by the impact of shot. The *New Ironsides* had a somewhat similar experience in an attack on Forts Wagner and Sumter on Aug. 16, and again on

[1] How rough an estimate this must be is apparent from the fact that the resistances of plates are nearly proportional to the squares of their thicknesses, and that this is owing to mechanical reasons which cannot apply to the penetration of coal, the resistance of which must be probably nearly proportional to its thickness.

[2] Development of Armour, Very, p. 387.

[3] *Ibid.*, p. 391.

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Sept. 10, 1863. Sand bags were found valuable on both occasions to prevent the flying of bolts and langridge. In a period of 6 months this ship was struck 193 times, and yet was never forced to go into port for repairs.

Numerous examples of the behaviour of ironclads of this date might be quoted from the report of actions in the American War. Speaking generally, it appears that injuries under the hottest fire hardly extended to more than the subsidiary parts of the vessel's armour, such as port-shutters, bolts, &c. Lieut. Very considers that evidence of weakness in laminated armour was ignored or slurred over. Captain (now Admiral) Simpson says—"The solid plates of hammered iron on the *New Ironsides*, though only 4½ inches in thickness, resist the impact of shot much better than the 5 inches of laminated iron on the sides of the monitors." "The laminated iron when disposed in a plane perpendicular to the flight of the projectile, does not seem to answer all demands; but when disposed in the form of a turret, no objection can be raised to it. The turrets are as near impregnable as any thing can be made. The only objection to them is the 'through bolts," which allow the nut to fly when the head of the bolt is struck." The most vital and dangerous part of this construction is the roof of the turret, which must be apparent to every one as weak. It can never be struck without causing damage. The roof of the *Weehawken* was struck at long range; the result was the fracturing of the thigh of one man and lighter wounds to two others.[1] Captain Simpson wrote a remarkable report on the evil of turret pilot house and spindle system in October, 1863, strongly recommending the base ring and anti-friction roller system long since adopted in England.

In February, 1868, during the war between Brazil and Paraguay the Brazilian monitor *Alagoas* was put to a very severe test; she carried on her sides 4½ inches solid wrought-iron plates backed with 15 inches of teak, and a ½-inch skin. Her turret carried 6-inch solid plates backed by about 10 inches teak and two ½-inch skin plates.[2] "In an attack on some Paraguayan batteries she was struck 200 times, her side armour being pierced 12 times and her turret twice. The armament of the batteries consisted of Whitworth 32-pr. rifles, 68-pr. and 120-pr. smooth-bores, and the range for the greater part of the time was less than 100 yards. The turret was very badly damaged; nearly all the bolts being broken, and the wood backing being badly crushed in several places."

Huascar actions.

In October, 1879, took place the fight between the Peruvian vessel, *Huascar*,[3] and the Chilian ships *Blanco, Encalado* and *Almirante Cochrane*. The *Huascar* was a single turret vessel, carrying 4½-inch iron armour, tapering down to 2 inches at bow and stern, backed by 10 inches of teak, and a ⅝-inch skin. Her turret had 5½ inches iron (solid),

1 Development of Armour, Very, p. 413.

2 Development of Armour, Very, p. 437.

3 The engagement between the *Shah* and the *Huascar* does not concern the purpose of this work further than to illustrate the bare fact that it is difficult to strike an adversary a full blow under the condition of an actual running fight and to show the effect of a common shell.

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13 inches teak, and ½-inch skin. Her conning-tower had 3-inch plates, backed by 8 inches teak, with two ½-inch skin plates of iron. The *Huascar*[1] having higher speed than any Chilian iron-clad vessel, had proved herself such a scourge, that the Chilian supplies had been cut off to a considerable extent. On May 21, 1879, she mercilessly riddled with shot, and rammed the unarmoured Chilian ship *Esmeralda*, one of whose boilers had been blown up, and who was almost drifting about. The Captain, Captain Pratt, and part of the crew of the *Esmeralda* desperately attempted boarding on the two occasions when the *Huascar* rammed her, but the boarding parties were overpowered and slain, and she sank with nearly all her gallant crew, with her colours still flying.

To capture the *Huascar* the Chilians had cleaned and repaired the *Cochrane*, and had improved her rate of speed so that she was at least as fast as the *Huascar*. Two divisions were formed, one led by the *Blanco*, and the other by the *Cochrane*, which were sister ships, carrying 9 inches of armour, and 12½-ton 9-inch guns. The *Blanco* and two other ships found the *Huascar* and another Peruvian vessel, and drove them north into the path of the *Cochrane*, and two fast unarmoured ships. Captain Grau, commanding the *Huascar*, tried to pass north-east of the *Cochrane*, but was cut off and exchanged shots while the *Blanco* was above four miles astern. It is now difficult to trace the exact course followed by the ships,[2] but it appears that the *Huascar* so far turned away from the *Cochrane* as to receive a most destructive fire from her heavy guns firing ahead, while the *Huascar's* fire was masked by her poop. A 9-inch Palliser shell from the *Cochrane* partly destroyed the conning-tower of the *Huascar*, killing Captain Grau and disabling the steering wheel. A similar shell penetrated the turret, killing most of the detachment, and a third entered the Captain's cabin, and destroyed the steering tackles and some men trying to work them. Now the *Blanco* came up and endeavoured to ram the *Huascar*, but passed astern of her, turning the *Cochrane* off her course, and causing her to make a complete circle to avoid collision. About the middle of her circle, a large shell, believed to have come from the *Blanco* by mistake, passed completely through the *Cochrane* abaft her battery, which, though it did not burst, did much damage, killing 2 and wounding 8 men. The *Huascar* was too far damaged to be able to avail herself of this opportunity to escape. The Chilian ironclads fired incessantly at her, their Nordenfelts cleared her deck, and "silenced the Gatling on her top. Another shell penetrated her turret, and bursting, splashed the left gun, killing the first officer and the men who were working it." The *Huascar's* steering tackles were destroyed a third time, and she soon after hauled down her flag.

[1] This is chiefly taken from Lieutenant Madan's spirited account in U. S. Institution Proceedings, 1881, No. CXII., p. 695. For *Cochrane*, *vide* fig. 3, p. 331.

[2] *Vide* also King's War Ships and Navies of the World, p. 439, and Development of Armour, by Very, p. 438. King states that the *Huascar* kept her stern purposely away from the enemy, while Madan blames the Captain for not doing so. King states the Captain of the *Huascar* endeavoured to ram the *Cochrane*, and also that the remains of the crew repulsed an attempt of the Chilians to board and complete their capture.

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Both the Chilian vessels fired Palliser filled shells. Out of 76 rounds from the 9-inch guns, and about 40 from lighter pieces, about 25 appear to have been effective hits, at least 16 of them being made with the 9-inch projectiles. The *Huascar* fired about 40 rounds with very little effect, only 3 striking the *Cochrane*, and inflicting no serious damage. The *Blanco* was untouched. Lieutenant Madan, R.N., who obtained his information from Chilian and Peruvian Officers, observes that "the weak armour of the *Huascar* appears to have been worse than useless, as although it deflected three or four 9-inch shells, and resisted the smaller projectiles, yet it enabled the Chilians to dispense with fuzes and use Palliser shell, which burst, after penetrating, with terrible effect."

By the rule of thumb, it may be seen that the 9-inch shot, even with 1300 feet velocity would be able to perforate about $\frac{9 \times 1300}{1000} = 12{\cdot}7$ inches of iron unbacked. It is evident therefore that up to the glancing angle these shot would perforate the armour of the *Huascar*, and the result was what must have been expected in any regular attack as far as the *Huascar's* armour was concerned. It might have been expected that at close ranges, the *Huascar* might have damaged the *Cochrane*, but not when running from her and striking her obliquely.

Effects of fire on *Huascar*.

Lieut. Madan enumerates the following injuries to the *Huascar*:—

(1.) Palliser shell entered forecastle, wrecked it, and broke stem.[1] (2) Carried away capstan. (3) Palliser shell glanced on turret, cutting a groove 1 inch deep. (4) Palliser shell entered turret compartment below upper deck on port side, burst over magazine hatch, choked turret machinery with *débris*, but it did no material damage, as it revolved easily afterwards. (5) Palliser shell struck edge of upper deck and burst, splashing turret with fragments. (6) Palliser shell entered turret to right of right gun, and struck right carriage bracket, and burst, killing, it is said, all men in turret. The gun might still have been fired perhaps with one capsquare, but it ceased firing. (7) Palliser shell entered turret to right of right gun near top, burst and struck left gun, injuring but not disabling it, and killing or wounding all the crew it is said. (8 and 9) Struck and destroyed conning-tower (3 ins. iron and 10 ins. backing) No. 8 disabled fighting wheel below. (10) Palliser shell glanced on funnel. (11) Palliser shell entered engine room, bursting, and killing 4 men on upper platform, but did not damage engines or men in charge. (12) Palliser shell struck a 12-pr. upper deck gun, knocking off muzzle. (13) Palliser shell burst inside officer's cabin. (14) Palliser shell entered poop. (15) Palliser shell burst in stern, cutting rudder chains, and killing men. (16) Palliser shell burst in stern, injuring stern post and killing all men on relieving tackles. There were many minor injuries.

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[1] These numbers are taken from bows to stern, not in their order of time. Lieutenant Madan obtained his facts from Chilian and Peruvian Officers, especially from the senior executive Officer of the *Cochrane*.

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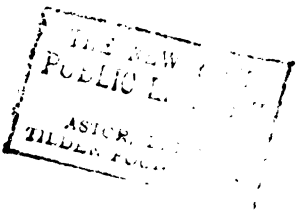

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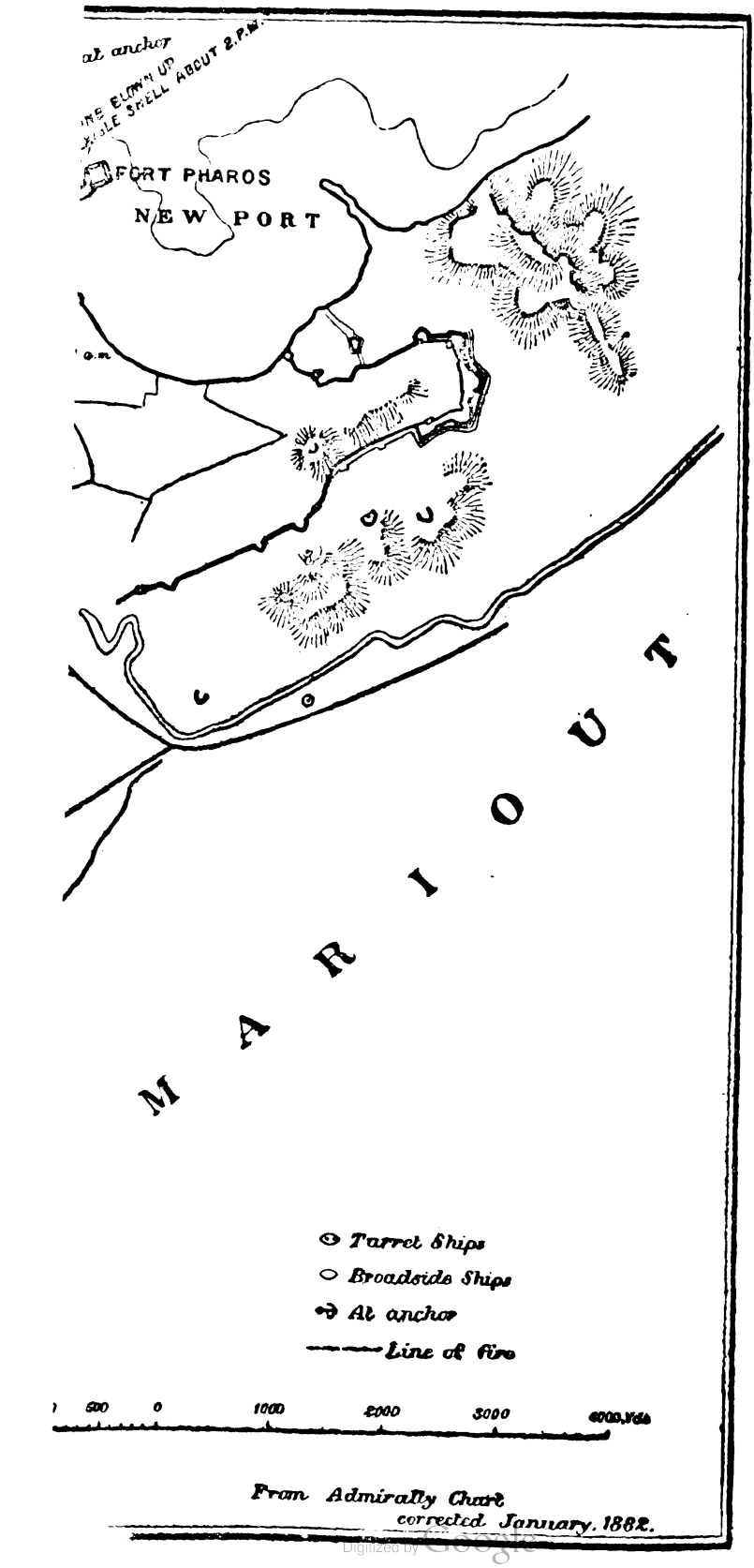

From Admiralty Chart
corrected January. 1882.

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Naval Attack of Alexandria Forts.[1]

The attack of the forts of Alexandria in 1882 should be studied in works specially devoted to it, such as the English and American official reports. Major Walford, R.A., read a very full paper on it at the United Service Institution.[2] Before discussing it briefly here, it is well to make one or two remarks as to its general character. First, it must be clearly understood that the case is not considered as an instance of a fight between ships and really powerful sea forts. A thoroughly well defended harbour would have mines laid down, rendering the movement of ships dangerous. The water would, perhaps, be divided up into imaginary squares, and mechanism might be provided for automatically directing guns on each spot. Possibly ships engaging at anchor might be assailed by rifled mortar or howitzer fire. Torpedo boats might also be encountered. In some cases there might be batteries on positions with high command. The existence of such elements would make an attack by sea a very serious matter, undoubtedly such an operation as would need special reasons to justify it.

In the case of Alexandria these dangers were not present, but complications and difficulties were not wanting; for example, circumstances demanded that the ships should be sparing of ammunition. The action was fought under conditions rendering it very difficult to distinguish the features of the forts, and to direct the fire to good purpose.

Moreover the vessels, with the exception of the *Inflexible*, were by no means the most heavily clad or powerfully armed possessed by England. The *Thunderer* class was wholly unrepresented.

The attack should be regarded, then, not as generally representative of what might occur, but as an important naval operation of a special kind whose complete success justified the judgment and skill with which it was conducted.

Certain British ships, the *Invincible*, *Monarch*, and *Penelope*, had been lying in the inner harbour of Alexandria up to July 10th, and they then moved into position in the outer harbour (*vide* plan, herewith). To this may be perhaps attributed the fact that the Egyptians laid down no submarine mines, for it appears that they had an abundant supply of them, although only a limited quantity of cable was found. The general character of the attack may be seen from Lord Alcester's orders, which were as follows:—

"There will be two attacks. (1) From the inside of the harbour, in which the *Invincible*, *Monarch*, and *Penelope*, will take part. (2) By the *Sultan*, *Superb*, *Temeraire*, *Alexandra*, and *Inflexible*, from outside the breakwater." . . . . "On the batteries opening on the off-shore squadron in reply, every effort will be made by ships to destroy the batteries on the Ras-el-Tin Peninsula, especially the light-house battery bearing on the harbour. When this is accomplished, the *Sultan*, *Superb*, and *Alexandra*, will move out to the eastward, and attack Fort Pharos, and, if possible, the Silsileh battery. The

[1] Extracted from Lord Brassey's Naval Annual, 1886.

[2] *Vide* U. S. Institution Proceedings, 1883, Vol. XXVII., No. CXIX.

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Inflexible will move down this afternoon to the position off the Corvette pass assigned to her yesterday, and be prepared to open fire on the guns in the Mex lines in support of the in-shore squadron when signal is made. The *Temeraire, Sultan,* and *Alexandra* will flank the works on Ras-el-Tin. The gun-vessels and gunboats will remain outside, and keep out of fire until a favourable opportunity offers of moving in to the attack of Mex."

The strength of the ships and forts that were to be thus engaged may be seen generally from the following Tables :—

Ship's Name.	Displacement in Tons.	Guns.									Armour. Maximum.	Draught of water
		80-ton 16-in.	25-ton 12-in.	25-ton 11-in.	18-ton 10-in.	12-ton 9-in.	9-ton 8-in.	6½-ton 7-in.	64-pr.	40-pr.		
Inflexible (Turret)	11,400	4	—	—	—	—	—	—	—	—	inches. 24 to 16	feet. $25\frac{1}{12}$
Monarch (Turret)	8,320	—	4	—	—	2	—	1	—	—	10 to 8	26
Temeraire (Barbette)...	8,540	—	—	4	4	—	—	—	—	—	11 to 8	$27\frac{1}{2}$
Alexandra.....	9,490	—	—	2	10	—	—	—	—	—	12 to 8	$26\frac{1}{2}$
Sultan	9,290	—	—	—	8	4	—	—	—	—	9 to 6	$27\frac{1}{2}$
Invincible.....	6,010	—	—	—	—	10	—	—	4	—	8 to 6	$22\frac{3}{4}$
Superb	9,100	—	—	—	16	—	—	—	—	—	12	$26\frac{1}{8}$
Penelope	4,470	—	—	—	—	—	8	—	—	3	6 to 5	$17\frac{1}{2}$
Total Guns... ...		4	4	6	38	16	8	1	4	3		

The batteries of Alexandria had the following armaments:—

RIFLED GUNS.

Forts and No. on Plan.	Mounted.					Unmounted.		Total.
	10-in. M.L.	9-in. M.L.	8-in. M.L.	7-in. M.L.	40-pr. B.L.	10-in. M.L.	9-in. M.L.	
Silsileh (1)	—	1	1	—	—	—	2	4
Pharos (2)	1	3	2	—	2	—	—	8
Adda (3)	1	3	1	—	—	—	—	5
Ras-el-Tin Lines (4)	1	3	2	2	1	—	—	9
Ras-el-Tin Fort... (4)	1	4	1	—	—	—	—	6
Oom-el-Kubeba (7) ...	—	—	2	—	—	—	—	2
Mex Fort (10)	1	1	3	—	—	2	4	11
Total	5	15	15	2	3	2	6	45

Mounted Rifled Guns in all ... 37 Unmounted Guns ... 8

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SMOOTH-BORE GUNS AND MORTARS.

Fort or Battery and No. on Plan.	Guns.			Mortars.				Total S. B. pieces.
	15-in.	10-in.	6·5-in.	20-in.	13-in.	12-in.	11-in.	
Fort Silsileh (1)	—	3	—	—	1	—	—	4
" Pharos (2)	—	6	31	—	4	—	—	41
" Adda (3)	—	14	—	—	5	—	—	19
Ras-el-Tin Lines (4)..	4	15	11	1	6	1	2	40
Fort Ras-el-Tin (4)..	2	5	21	—	1	—	2	31
" Saleh Aga (5).....	—	4	8	—	—	—	—	12
Battery (6)	—	2	2	—	—	—	—	4
Fort Oom-le-Kubeba (7)	—	6	10	—	1	1	—	18
" Kamaria (8)	—	2	3	—	1	—	—	6
Mex Sea Lines (9)	4	11	9	—	—	—	—	24
" Fort (10)	—	4	5	—	3	2	—	14
Mounted S. B. Guns in all ... 182				Mounted Mortars ... 31				213

It may be seen from the above Tables that while the guns of the fleet were much more powerful than those of the forts, some of the latter might, under reasonably favourable circumstances, perforate the armour of all the ships except the *Inflexible*.

The guns and projectiles were supplied from Elswick, and correspond to the service old type Woolwich M. L. armaments carried by the British vessels.

On the morning of July 11th, 1882, at about 7 a.m., the British fleet opened fire in the order detailed by Lord Alcester. The position of the ships may be seen approximately in the plan.

The *Invincible* (flagship) and *Penelope* engaged at anchor in the outer harbour against the earthworks at Fort Mex at 1500 yards range. The *Monarch* acted with them under steam against Forts Mex and Oom-el-Kubeba, as well as eleven gunboats. The *Temeraire* supported the attack from the central pass into the harbour at about 4000 yards range, and the *Inflexible* in the Corvette pass divided her fire between earth and masonry forts, Oom-el-Kubeba at 4000 yards, and Ras-el-Tin at 2700 yards. The *Alexandra*, *Superb*, and *Sultan*, engaged all forts between Ras-el-Tin and Pharos, chiefly, at first under steam, at from 1500 to 2000 yards, and at length anchored at about 2200 yards distance. The gunboats, *Helicon*, *Condor*, *Beacon*, *Bittern*, *Cygnet*, *Decoy*, assisted as opportunity offered.

At about 10.30 a.m., Ras-el-Tin and Mex Forts were to a great extent silenced, and the *Alexandra*, *Sultan* and *Superb* attacked the centre battery and other forts farther to the east, the *Inflexible* and

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Temeraire coming round and joining in the work. The *Superb* attacked Adda; the *Temeraire*, Pharos; and the *Inflexible*, both these forts. A shell from the *Superb* blew up the magazine in Adda, and silenced it about 2 p.m. The *Monarch* had silenced Oom-el-Kubeba about 1 p.m. The *Temeraire*, *Inflexible*, and *Superb*, silenced Fort Pharos about 2.30 p.m., and the centre battery ceased to reply to the *Sultan* and *Alexandra* about the same time. A battery at Hospital or Bluff Point was the last one silenced at about 3 p.m. At about 1 o'clock a party in a boat very gallantly landed and destroyed the guns in Fort Mex.

Effect of fire on forts.

The effect of the ships' fire on the various works was as follows:—

Fort Silsileh (not much engaged), a regular fort, chiefly earthwork, suffered little damage.

Fort Pharos, masonry with casemates, suffered severely, casemates riddled and choked. Three guns and carriages wrecked and others choked. One gun on the reverse face carried away and thrown on to its muzzle in the ditch 30 ft. distant. The rifled guns were silenced before the smooth-bores in the casemates, although the loss of life in the latter must have been out of all proportion to that in the former.

Fort Adda, earth revetted with masonry. Parapets cut about but not materially injured. Three guns struck and put *hors de combat*. The fort was wrecked by the explosion of the magazine, otherwise it might have continued firing.

Ras-el-Tin Lines (from Hospital Battery to Ras-el-Tin Fort). Masonry and earth. No guns actually disabled although struck; several put out of action by being dismounted; or by the carriages being broken, or choked with *débris*.

Ras-el-Tin Fort (masonry and earth, but with thin parapets). All rifled guns fairly put out of action, either by fire of the fleet or by accident. This fort fought better and suffered more than any other. The parapets were much cut about and buildings riddled.

Fort Saleh Aga an insignificant work, but with a command of 60 feet. One S. B. gun dismounted.

Fort Oom-el-Kubeba 80 ft. command, masonry and earth, with good profile. Parapet suffered much from *Inflexible* 80-ton gun shells. One gun destroyed.

Fort Kamaria untouched, probably did not engage in action.

Mex Sea Lines, about 25 feet highest command; guns firing *en barbette* over earth parapets, 15 to 18 feet thick. One or more guns dismounted by fire of ships.

Mex Fort, 22 feet command; guns *en barbette*; earth parapet unrevetted; parapets hardly injured, but buildings almost swept away. Three guns struck by shells and put out of action, and others by machine gun or shrapnel bullets. Two 10-inch guns received great protection from a wall some distance in front, which caught shells aimed at the guns; both the latter were struck, but not materially injured.

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Fort Marsa-el-Kanat had no defensive power. Fort Marabout was attacked by gunboats. No guns were dismounted.

Effect of fire on ships.

The ships received the following injuries :—The *Inflexible,* penetrated in unarmoured parts, and a good deal knocked about aloft. *Monarch* and *Temeraire* untouched. *Alexandra,* struck sixty times, but not seriously injured. *Sultan, Invincible,* and *Superb,* armour indented, and minor injuries sustained.

The *Penelope* hulled eight times, but no serious injuries caused. A small slice cut off one gun near the muzzle.

Conclusion.

The *American Official Report,* written by Lieut.-Commander Goodrich, contains among other conclusions—

American report.

(1) Command is important for forts. (2) 30 feet of earth stops all projectiles. (3) Embrasures should be cut deep below crest. (4) No guns should be mounted *en barbette.* (5) Guns should be painted the colour of the works. (6) The value of armour has been under-rated. (7) Modern guns with flat trajectories are not the best for attacking earthworks. (8) Some ships should carry howitzers. (9) Vertical fire should be studied. (10) Disappearing guns firing *en barbette* are very efficient. (11) Ships gain more in accuracy by anchoring than they lose in increased exposure to injury. (12) The swell told against the shooting, especially of ships engaging broadside on. (13) Shot not aimed at guns or magazines are thrown away. (14) Vessels do not fight on even terms with forts. (15) Forts could not stop ships. (16) The forts might have been repaired and action continued.

Mj. Walford

Major Walford, R.A., forms conclusions agreeing with some of the above, and points out the advantage of counter-guards in advance of batteries, also of traverses, parados, and mantlets, and the evil of stone and brick in batteries. He recommends guns being strongly pivoted, well forward.

The additional suggestion may perhaps be made, that forts might mask or reserve their most powerful guns until they had drawn a large quantity of the ships' ammunition. It would be difficult for a fleet to detect such a practice, and the masked guns might obtain a better opportunity of damaging ships, if the latter became emboldened to draw in to closer range.

Admiral Le Hunte Warde.

Special causes, as noticed before, made accurate firing from the ships almost impossible. The conditions of sunlight and of the works made it very difficult to distinguish the guns and objects aimed at. Admiral Le Hunte Warde, who commanded the *Superb,* states that while the vessels were in motion, it was necessary, as fast as the smoke cleared, to identify objects aimed at from a new point of view, and then to fire at them at an altered range. So difficult was this, that to deal effectually with the forts it was judged necessary to anchor.

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ARTILLERY FIRED FROM RAILWAY WAGONS.

Result of Artillery experiments during the Camp of Exercise at Delhi, on the 17th, 19th and 20th of January, 1886.

COMMUNICATED BY

D.-A.-GENERAL, R.A.

THESE experiments were conducted on the main line of the Rajputana-Malwa Railway, at the 3rd mile stone from Delhi, and opposite the military siding.

The ordnance used on each occasion was a 40-pr. B. L. gun, mounted on a wooden naval gun carriage.

The railway trucks used were the lightest and heaviest descriptions of low-sided wagons in use on the Indian metre-gauge railways, namely :—

I. A military low-sided wagon, having wrought-iron underframes, and timber sides, ends, and floor; the sides and ends arranged to fall flush with the floor. The inside dimensions of this wagon were 13 feet 5 inches by 6 feet 3½ inches. The unloaded weight of the wagon was 2·87 tons, and the gross weight (including the load) was 9 tons. It was mounted on 4 wheels.

II. A low-sided grain wagon constructed entirely of wrought-iron (except the axle boxes) mounted on two American type bogie frames; each bogie frame mounted on 4 wheels,—or the whole wagon on 8 wheels. The floor dimensions of this wagon were 25 feet by 7 feet.

Its unloaded weight was 5·36 tons. The axles and bearing springs were strong enough to bear a gross load of 24 tons.

FIRST SERIES—January 17th, 1886.

Officers present :—

LIEUT.-COL. WALLACE, R.E., *Consulting Engineer.*

MAJOR BISSET, R.E., *Agent, B. B. and C. I. Railway.*

CAPTAIN MOBERLY, R.A.

MR. MCIVOR, C.E., *District Engineer, R.-M. Railway.*

Mr. W. R. S. JONES, *Carriage and Wagon Superintendent, R.-M. Railway.*

Experiment No. 1. (*Empty wagon*).—40-pr. B. L. gun shotted, mounted on a low-sided military type wagon, as shown in accompanying

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diagrams, Figures 1, 2 and 3, floor covered with deodar sleepers, side at rear of gun strengthened by teak bar 12 inches × 4 inches.

		Tons.
Weight of	wagon complete	2·87
	sleeper floor	0·46
	side bar	0·1
		3·43
„	gun and carriage	2·6
	Total weight ...	5·03

Preparation for 1st shot.—Ballast under horn plates of wagon cleared to allow wood packing to bear on road sleepers, space between wagon horn plates and road sleepers tightened with wood packing.

Position of Gun.—Over centre of leading wheels, gun laid to fire broadside to wagon, height of centre of gun trunnion from surface of rails, 6 feet 2 inches.

Result of first shot.—Recoil of gun caused wagon to rock backwards and forwards dangerously on the packing placed between the road sleepers, and the horn plates. Body corner knees bent; no further damage to wagon.

Preparation for 2nd shot.—Two sleepers placed as props, as shown by the dotted lines in Fig. 3.

Position of Gun.—Same as for 1st shot.

Result of 2nd shot.—Recoil of gun caused props to radiate upwards; to lift the wagon with a torsional movement, and to derail the trailing wheels of the wagon—no further damage to body knees, or other parts of wagon.

Preparation for 3rd shot.—The wagon was quickly re-railed, the props were removed and timber packings were placed to within one inch of the wagon horn plates.

Result of 3rd shot.—Recoil of gun caused wagon to heel heavily on the timber packings placed under the horn plates, and to rebound forward; but the wheels returned to their places on the rails. No further damage to the body knees or to any of the wheel or other gear of the wagon.

SECOND SERIES—January 19th, 1886.

Officers present:—

Lieut.-Col. Wallace, R.E., *Consulting Engineer.*
Major W. S. S. Bisset, R.E., *Agent, B. B. and C. I. Railway.*
Captain Moberly, R.A.
Mr. MacIvor, C.E., *District Engineer, R.-M. Railway.*
Mr. W. R. S. Jones, *Carriage and Wagon Superintendent, R.-M. Railway.*

Experiment No. 2 (Empty Bogie Wagon).—40-pr. B.L. gun shotted, mounted on an iron low-sided bogie wagon, as illustrated in the

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accompanying diagrams, Figs. 4, 5 and 6. Portion of floor covered with deodar sleepers. Props of deodar (old sleepers) secured by four tie rods 1-inch diameter, in the manner shown, to the sides of the wagon in front and rear of gun when placed to fire broad-side to the wagon.

		Tons.
Weight of	wagon complete	5·36
	sleeper platform	0·60
	side props	0·09
		6·05
„	gun and carriage	2·6
	Total weight ...	8·65

Preparation for 1st shot.—Ballast cleared from underneath horn plates of wagon, to admit of wood packing being placed on the road sleepers. Distance between horn plates and top of packing $1\frac{3}{4}$ inches.

Position of Gun.—Over centre of leading bogie truck, and chained to front side props, gun laid to fire $1\frac{1}{2}$ degrees of lateral deviation from broadside.

Height of centre of gun trunnion from surface of rail 6 feet 4 inches.

Result of 1st Shot.—Recoil of gun caused wagon to heel over and bear heavily in the packing placed between the horn plates and the road sleepers, and to break one of the temporary props fastened to the side of the wagon; no damage to working gear of wagon.

Preparation for 2nd Shot.—Gun laid as for first shot in this series, space between horn plates and top of packing placed on sleepers, 3 inches; putty tell-tales placed on top of horn plate packing.

Result of 2nd Shot.—The recoil of the gun caused the wagon to heel over 2 inches in the rear, and $\frac{3}{4}$ of an inch in front of the gun.

THIRD SERIES.—January 20th, 1886.

Officers present:—

COLONEL MINTO ELLIOTT, R.A., *Adjutant General of Artillery.*
LIEUT.-COL. WALLACE, R.E., *Consulting Engineer.*
MAJOR W. S. S. BISSET, R.E., *Agent, B. B. and C. I. Railway.*
CAPTAIN MOBERLY, R.A.
MR. MCIVOR, *District Engineer, Rajputana-Malwa Railway.*
MR. W. R. S. JONES, *Carriage and Wagon Supt. R.-M. Railway.*

Experiment No. 3 (Weighted Bogie Wagon.)—40-B.L. gun shotted, mounted on an iron low-sided bogie wagon as illustrated in the accompanying diagrams, Nos. 7, 8 and 9. Floor covered with rails, on top of which deodar sleepers formed a platform, props of sal 24 inches × 12 inches placed in front and rear of gun carriage, and secured to

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the sides of the wagon by four tie rods one-inch diameter, placed to take the recoil of the gun when the latter was laid to fire broadside to the wagon.

		Tons.
Weight of	empty wagon	5·36
	sleeper platform	0·87
	side props and tie bars ...	0·31
	rails	10·0
		16·54
„	gun and carriage	2·6
	Total weight ...	19·14

Preparation for 1st Shot.—Ballast cleared from underneath horn plates of wagon, to admit of wood packing being placed on road sleepers. Distance between horn plates and top of packing ranged from 2½ to 3 inches; putty tell-tales placed in packings of leading bogies.

Position of Gun.—Over centre of leading bogie, (as for second series) tackle of gun secured to the front side props; gun laid to fire broadside to wagon; height of centre of gun trunnion from surface of rails 7 feet and ½ an inch.

Result of 1st Shot.—Recoil of gun caused wagon to deflect the bearing springs $\frac{7}{16}$ of an inch in the rear, and $\frac{3}{32}$ of an inch in front of the gun; no deflection in the springs of the trailing bogies. The tackle fastened to the front props seemed to take the whole of the recoil of the gun; two of the lower tie rods (which secured the props to the side of the wagon) gave way, allowing the gun to recoil 10 inches beyond the rear side of the wagon. Wheels of wagon did not move from their positions on the rails; no damage to any of the details of the wagon.

FOURTH SERIES—January 20th, 1886.

SAME OFFICERS PRESENT AS FOR THIRD SERIES.

Experiment No. 4 (weighted low-sided wagon.)—40-pr. B.L. gun shotted, mounted on a low-sided wagon, as illustrated in the accompanying diagrams, Nos. 10, 11 and 12. Floor covered with rails, on top of which deodar sleepers formed a platform. Tie rods connecting the sides of the wagon together were placed at the extreme ends of the wagon; in other respects the wagon was the same as in the first series.

		Tons.
Weight of	empty wagon	2·83
	side bar	0·1
	sleeper floor	0·67
	rails	4·0
		7·6
„	gun and carriage	2·6
	Total weight ...	10·2

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Preparation for 1st Shot.—Ballast cleared from underneath horn plates of wagon to admit of wood packing being placed on the road sleepers. Distance between horn plates and top of packing, and of rear packings $2\frac{1}{4}$ and $2\frac{3}{8}$ inches respectively; between front packings 2 inches and 1 inch respectively. Putty tell-tales placed in front and rear packings.

Position of Gun.—In centre of wagon, and laid to fire broadside to wagon; tackle secured to ring bolts in floor, height of centre of gun trunnions from surface of rail, 6 feet $10\frac{1}{4}$ inches.

Result of 1st Shot.—Recoil of gun caused the wagon to heel over and touch the rear packings lightly, and, by reaction, to deflect the bearing springs $\frac{1}{8}$ of an inch in front of the gun.

Preparation for 2nd Shot.—Space between horn plates and packings increased to 3 inches. Putty tell-tales placed on packings.

Result of 2nd Shot.—Recoil of gun caused the wagon to heel over in the rear of the gun $1\frac{5}{8}$ inches and $1\frac{7}{8}$ inches respectively, and the reaction deflected the bearing springs in front of the gun $\frac{15}{16}$ and $\frac{7}{8}$ inches respectively.

Gun rocked considerably, wheels of wagon on front side of guns lifted about 2 inches from the rails, rear wheels did not move; no damage to any of the details of the wagon.

Remarks by the Carriage and Wagon Superintendent, Rajputana-Malwa Railway.

These experiments prove:—

1. That 40-pr. guns cannot be safely fired from either:—
   (*a.*) Small empty wagons mounted on four wheels.
   (*b.*) Small wagons weighted up to 10·2 tons.
   (*c.*) Empty bogie wagons mounted on eight wheels.

2. That a bogie wagon loaded to 19·14 tons was perfectly stable when fired from broadside with a shotted 40-pr. B.L. gun; when so loaded and fired, the deflection of the wagon bearing springs was actually less than half an inch.

The Carriage and Wagon Superintendent, Rajputana-Malwa Railway, is therefore of opinion that an armour train carrying heavy ordnance is perfectly feasible on a metre-gauge railway; and provided that weighted bogie trucks are employed for the heavy guns, such weighted wagons are perfectly stable on their own wheels, and need no props or other supports.

The present working widths of metre gauge vehicles are too narrow to admit of the free working of heavy guns. But, in war time, they could be made of any width up to 8 feet 6 inches outside dimensions,

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without fear of coming in contact with any fixed structures. Existing four-wheeled covered vehicles, when armour-plated, would have ample space in which to work Nordenfelt guns, as well as for Infantry.

W. R. JONES,
Carriage and Wagon Superintendent,
Rajputana-Malwa Railway.

Remarks by the Agent, B. B. and C. I. Railway.

Mr. Jones' memorandum gives full details of the experiments:—

I concur with him that it would be dangerous on active service, where an accident would endanger the capture of the armoured train, to fire broadside a 40-pr. gun, mounted on such a carriage as was tried at Delhi, from off an ordinary four-wheeled metre-gauge wagon, whether light or loaded.

My observation of the results of the 2nd and 3rd series of experiments did not lead me to differentiate so strongly, as Mr. Jones has done, between the degree of safety in firing from the empty and loaded bogie wagon. Both were moderately safe.

My opinion is—

That to ensure safety from heeling over, clips should be used to clamp the wheels of the wagon to the rails, leaving the body and springs of the wagon free.

That a special gun carriage should be devised (as low as possible) with a hydraulic or other check to recoil, and of suitable dimensions to allow of its being traversed freely in an ordinary metre-gauge wagon. Such a carriage is wanted for Field Artillery, as well as for the 40-pr. gun.

That with these arrangements, an armoured train can be satisfactorily used on metre-gauge rolling stock, and that a 40-pr. gun, though inconveniently large, can be safely fired even broadside from bogie wagons, and probably, by using the clips suggested, from four-wheeled wagons also.

W. S. S. BISSET, MAJOR, R.E.,
Agent, B. B. and C. I. Railway.

From—CAPTAIN W. F. G. MOBERLY, R.A., late in charge of armoured train.
To—The Officer Commanding Royal Artillery, Rawal Pindi Division.

Rawal Pindi, 20th April, 1886.

I have the honor to forward a report on experiments carried out with 40-pr. R.B.L. gun on metre-gauge railway wagons, in the neighbourhood of Delhi.

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2. The gun was mounted on a wooden garrison standing carriage, altered as already reported, and not on a naval gun carriage as stated in the printed report.

3. I do not think that a heavy field gun could be fired from any of the wagons tried, mounted in the manner in which the 40-pr. R.B.L. gun was mounted, as although, when the gun was fired from the loaded bogie wagon as described in 3rd series, the springs were not seriously deflected, the oscillation of the wagon was so great that the gun, after recoil, ran itself up again as far as it would go, and I do not think that the men necessary to work the gun could have stood in the wagon.

4. The wagons are far too narrow for the efficient working of the gun. It was found impossible to traverse the gun through a right angle without lowering the side of the wagon to enable the rear of the gun carriage to pass outside altogether. This could not be done if the truck was armour-plated.

5. The wagon was so narrow that the gun could not be fired at all except along the line of rails, and at right angles to it, unless the sides of the wagon were made sufficiently strong to bear the whole shock of discharge when the rear of the carriage was against the side of the wagon.

6. I think that by an adaptation of the carriage and platform for S.B.B.L. 32-pr. 42-cwt. gun, as described in "List of Changes in War Matériel, Home, 4509," issued with "Army Circular," dated 1st July, 1882, to enable the platform to be traversed on a central pivot, a gun could be mounted on a metre-gauge wagon by slightly curving the sides, making them fish-bellied in shape.

7. By the use of such a carriage and platform the working of the gun would be much facilitated, as experience showed that it was very hard to work the 40-pr. R.B.L. gun in such a confined space. It would be necessary to fit suitable elevating gear to the carriage, as, when firing at right angles to the lines of rails, handspikes could not be used for elevating, owing to the very limited space.

8. Moreover, with such a carriage and platform, the shock of discharge would be more evenly distributed over the whole of the floor of the wagon, and the oscillation would be very much diminished; if a bogie wagon were used, the racers could be laid so as to be over one of the bogie carriages, thus materially strengthening the floor, and diminishing the oscillation.

9. When the train was in motion the gun could be traversed into a position parallel to the line of rails.

10. Printed report and diagrams attached.

No. 593, dated Rawal Pindi, 30th April, 1886.

Forwarded to the Deputy-Adjutant-General, Royal Artillery.

M. W. OMMANNEY, *Lieut.-Colonel,*
Commanding Royal Artillery, Rawal Pindi Division.

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STABLE MANAGEMENT IN INDIA.

BY

MAJOR G. W. M. TURNBULL, R.H.A.

As a great deal has lately been written about stable management in India, I venture to give my experience as to the chief causes of horses of batteries and regiments losing condition. I think the reason will probably be found in either one or other of the following points:—

1. They do not get their full allowance of gram.
2. Feeding during stable hours.
3. Feeding out of nose-bags either in barracks, camp, or line of march.
4. The gram is soaked too much.
5. Insufficient bedding.
6. Insufficient grooming.
7. Use of pots or pans by syces.
8. Insufficient water.
9. Insufficient grass and of bad quality.

The gram has to go through several hands before it reaches the horse. The contractor can give short weight if the N.-C. officers who see it weighed stand in with him. The line orderly can steal it, the men grinding it can do likewise. The first can be checked by an officer having it re-weighed at odd times during the week. The two latter can be prevented by proper precautions.

The gram shed ought always to be locked, except at feeding times, and the key kept by the Sergeant-Major. When the gram is being ground the syces performing the work should be locked inside, care being taken that no gram can be passed out of the windows.

Some years ago on joining a battery, I found the horses not looking well, so set to work to try and find out the cause, but for a long time could discover nothing. One day as I was riding near the gram shed I saw a woman with a bundle coming from the direction of it. I found the bundle contained gram. I got off my horse and went quietly up to the gram shed and discovered the wife of a syce (who was inside grinding gram) holding a little child up to the window and the father passing gram into his hands. The door of the shed was locked, and the windows closely barred, but there was just room for a very small child's

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hand to pass between. I quote this to show how careful supervision must be. I expect a large amount of gram had been stolen continually in this manner. After this discovery the horses daily improved in condition.

Gram should be of the best quality, free from dirt, *kunkhur* and mouldy grains, and free from weavil.

Feeding during stable hour is a mistake; a horse likes to be quiet when feeding; some batteries feed at the stable hour, for fear syces should steal the gram in the absence of the Europeans. I do not believe this, if proper precautions are taken. One European per subdivision ought to be told off daily to see the horses fed, and if this duty is properly performed their is little or no fear of any stealing taking place.

In my opinion horses ought never to be fed out of nose-bags; they swallow a lot of wind and lose a great deal of their feed by chucking their heads up, and do not digest so well as when fed out of troughs or on blankets. If there are no troughs the horses should be fed out of blankets, and the syces should always sit at their horses heads while they are feeding so as to prevent them wasting their food or fighting with their neighbours.

Gram ought only to be moistened, and directly it is mixed it ought to be given to the horses as it soon gets sour. In the cold season the best feed in my experience is three-quarters gram and one-quarter bran with a handful of chaff; if the latter cannot be obtained a little *bhoosa* is an excellent substitute. In the hot weather one-half bran and one-half gram. A little salt ought to be mixed with each feed. The chaff keeps a horse from bolting his food and thus makes him digest better. Three or four pounds of carrots should be given every day when procurable and funds admit of it. A few pounds of lucerne occasionally is an excellent thing.

A good bed I consider is equal to an extra feed; the Government allowance is very small, some six or eight lbs. a-day, according to the season, but arrangements should be made to buy straw, or some substitute, when it is cheap, and stack it; if the grass fund is properly managed there ought to be enough money for the purpose.

No horse can look well unless he is thoroughly groomed, and great care should be taken that during stables there is no idleness. A thing that is sometimes overlooked is litter marks, these should be removed after picking out feet. The extremities of a horse are sometimes neglected,—I mean manes, tails, and legs, these should shine like the body. Europeans dislike stooping down to groom, natives on the other hand like it. A good plan is to have the last ten minutes at morning stables for all hands to groom legs. At evening stables ten or fifteen minutes should be given to wisping, and every wisp made to tell. Wisps are better old than new. Ten minutes ought to be given for manes and tails.

Horses ought never to be made to stale in pots or pans. For example:—a horse wants to stale, the pot is perhaps lying some little distance off; the man gives him a dig in the ribs and goes for the pot, when he returns probably the horse will not stale, so eventually the

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horse learns to retain his urine until the pot is held for him, an obviously bad practice. The best plan is to let a horse stale in his natural way. Two boxes, one of dry earth and one of lime, ought to be kept in each sub-division, when a horse has staled, some dry earth should be thrown over it and the soaked earth swept to the rear and carried away. Some dry lime should then be thrown under the horse.

In passing I may mention that in the season when flies swarm, the horses are terribly worried by them; if there is sufficient money in the funds a light cloth ought to be given to each horse, large enough to cover the body and tie close under the belly. This is an immense relief to the animals; go round stables at this time of year, with horses with nothing on, and you will find them stamping and whisking their tails about to get rid of the flies; go round the same when clothed as suggested and you will find them comparatively at ease. Small piles of litter well damped should be lighted behind every six or eight horses and the smoke will drive a large number of the flies away.

The greatest care should be taken that horses have enough water. Some drink very slowly. I have often noticed both Europeans and natives taking away horses before they have finished drinking. After a horse has taken a good gulp and pauses to take breath, he gets a jerk in the mouth and is taken back to the lines, instead of letting him rest before taking more water. An officer should go at uncertain times when the horses are being watered. Horses should be watered about one hour before feeding.

Grass should be of the best quality. The kind varies in different parts of India. *Dhoob* is the best. Great care should be taken in weighing it, and every bundle should be opened to see it is good throughout; it never should be washed under any circumstances, if it is wet it must be well dried before it is given to the horses. It should be well beaten to remove any earth that is attached to it. Grass for every two horses ought to be in a bundle in rear of them, if this is not done and it is left in rear of a sub-division in bulk, some horses will get too much, others too little.

In conclusion I would state that some farriers throw a horse for shoeing if he is at all troublesome, this ought never to be allowed. Any horses that give trouble should be taken to the forge daily and have their legs and feet handled, and given a little lucerne; they will soon be able to be shod with but little difficulty.

I hope the foregoing remarks may induce others, better able than myself to deal with this most important subject, to bring forward their opinions on a matter where such diversity of opinion exists.

UMBALLA, *Nov.*, 1886.

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COMMANDER MERYON'S

SHOEBURYNESS LECTURES.

A CRITIQUE.

BY

CAPTAIN G. S. CLARKE, R.E.

The rivalry between coast defences and ships of war has given rise to much interesting discussion at various times; but the naval aspects of the question have not too often been presented in a definite form. We have learned to be accustomed to rather airy statements at the U. S. Institution and elsewhere, as to what ships are going to do, and the ably planned attacks on our two greatest home fortresses, which Captain Meryon has given us, are welcome in all respects. To theorize in the dark, as we landsmen are perhaps too prone to do, is never quite satisfactory. It is useless for us to prescribe the manner of naval operations and proceed to design defences to meet it. Our coast defences, if they are attacked at all, will be attacked by naval men in accordance with their own methods and with the lights of their day. It is these methods which we must seek to oppose. Thus the association, in the work of designing coast defences, of minds accustomed to the point of view of the attack is essential to a scientific treatment of the varying problems which present themselves for solution, and in the absence of that association, errors of more or less importance become inevitable.

Having disposed of Plymouth, Captain Meryon concludes his first lecture as follows:—"Directly you decentralize the guns of the defence and place them behind earthworks, and adopt thoroughly efficient means of concealing them besides withdrawing them from positions at which they can be engaged at short range, any such method of attack as I have described falls through." In other words the existing defences of Plymouth are, in Captain Meryon's view, just such as a sailor would wish to engage, and it would be interesting to know whether this opinion was held by naval men generally 25 years ago, and if so, to what extent it was taken into account in the halcyon days, when funds for coast defence were available on a regal scale.

The object sought to be attained in criticizing these valuable lectures, is merely to show in what respect the power of the defence

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appears to have been underrated, and where the attack may possibly have benefited from its advocate's natural predilections.

Captain Meryon premises that an attack on "the strong military and naval centres of this or any other country is a very improbable occurrence; their very strength renders it advisable for an enemy to adopt any other means of striking vital blows at an adversary." This is all very true and, in the light of experience, it would be a highly questionable policy to embark on an attack on Kronstadt. In the case of Great Britain, however, the real and substantial advantages which would accrue to an enemy from a successful attack on Plymouth or Portsmouth are so great that no excuse is needed for seriously considering all the possibilities which present themselves.

The method prescribed in operating against Plymouth is that of "attack at full speed and short range." Such a method is considered to be applicable also in the cases of Cherbourg, Malta, and Aden; since, in these fortresses, "the forts face the open sea." Portsmouth, on the other hand, is placed in another category with Kiel, Kronstadt, Wilhelmshaven, Brest, and Milford Haven. The distinction turns mainly on the superior facilities for submarine mine defence ascribed to the latter class and, in the contrasted cases of Portsmouth and Plymouth, must apparently be based on the advantages for laying down mines which the shelter of the Isle of Wight confers. Otherwise, Plymouth with its narrow deep entrance—700 yards wide between Picklecombe and the Breakwater—and the range of commanding artillery positions from Rame Head to Mount Edgcumbe as well as above Bovisand, is, according to a landsman's view, infinitely more defensible than the eastern approach to Spithead.

Certain definite conditions are laid down as essential to the successful application of the method to Plymouth. The attack is to be carried out "by an energetic Admiral immediately on the outbreak of war." The armament of the forts is to be "not quite complete," "the torpedo defence not quite organised," "the Intelligence Department not exceptionally good," "the bulk of the English fleet" with "every available torpedo boat," has been "drawn off to the Mediterranean." Some of these conditions are only too likely to be realized. Our armaments are never likely to be "quite complete." Mine defences, though completely organized, may not have been fully laid out owing to the continuance of bad weather. But, on the other hand, the complete and absolute denudation of all naval defence is less easy to conceive, though its absolute impossibility is not by any means asserted. If ten first-class French iron-clads are cruising in the Channel, the Mediterranean would not be the place for the "bulk" of the British Navy in case of strained relations with France. If troubles with Russia or Germany threatened, the Channel ports might fairly count on some measure of naval defence. At least, a few torpedo boats might be expected to be available in Hamoaze. The combined hostility of France and Italy does not at present come within the range of practical politics.

The preliminary conditions of attack, as laid down by Captain Meryon, may nevertheless be granted with slight qualification. The

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sudden advent of the enemy before Plymouth in the early morning is an eminently fair assumption. Steam has destroyed the restrictions which governed our last French war, and during hostilities with a naval power, any English port may expect the appearance of an enemy's squadron at daylight any morning. It is less easy, however, to assent to a further condition not specified; but apparently implied. While the attack is to derive the very fullest advantage from medium, quick-firing, and machine guns, the defence is—perhaps too arbitrarily—deprived of their assistance.

The plan of attack is simple and—the defence apart—eminently practicable. The ten iron-clads form in two quarter lines, and the Admiral leading the port division, steers just clear of Penlee Point heading for the centre of Picklecombe. In this order, the enemy advances at 12 knots speed until the flag ship arrives at 500 (or 800 ?) yards from Picklecombe. The port division then turn to port, "sweep round Cawsand Bay" and, "having stopped, engage the forts." The starboard division simultaneously sweep round to starboard and engage the Breakwater Fort. The iron-clads apparently fire only "one or two rounds" in their advance, but engage Picklecombe and the Breakwater with their respective starboard and port broadsides as they successively alter course outwards. Subsequently, the firing continues for 15 minutes, after which the Admiral decides either to withdraw and repair damages or to continue the attack. Meanwhile, the cruisers, of which there are six, advance on Bovisand in line abreast and turn their broadsides at 4000 yards, after which they appear to continue the action "steaming about eight knots east and west" and presumably maintaining this respectful distance.

It is impossible for several reasons to follow Captain Meryon in his speculations as to the result of the above manœuvres. In the first place he altogether ignores the two 38-ton guns in No. 4 Redoubt on Maker Heights. These guns at a height of 320 feet above the sea bear on all the water in which the ironclads operate—the port division passing only 1600 yards in front of them. They have plenty of time for cool shooting. Even the Ruggiero could hardly afford to despise the 820 lb. shells, and these two guns might quite conceivably play a decisive part in the action. We know that the Telegraph battery at Sebastopol, at an elevation of only 100 feet above the sea, practically put six British ships out of action "without itself having a gun dismounted and without losing one man."[1] No. 4 Redoubt might prove equally dangerous. There is the less reason for ignoring these guns, since there has been no attempt to conceal them; and, with an open-hearted generosity only too rare, they have been mounted in a veritable fort dating back somewhere into the dark ages. Cawsand battery also has been spirited away on the principles which apply in a sham fight; but are not usually regarded amid stern realities. The armament of Cawsand is confessedly indifferent, but at the ranges at which the port division manœuvres, even a 64-pr. is not to be entirely neglected; while, if the case of Meks affords any teaching, this work would require

[1] Kinglake.

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a vast amount of iron to silence it. At least, if the medium, quick-firing and machine guns of the attack are allowed to work their sweet will, something must be conceded to Cawsand. Further, Drake's Island receives no recognition; though its 25-ton guns bear at about 2300 yards on the ironclads, as they change course and turn their broadsides. An ironclad, though—happily for itself—*not* a Picklecombe, offers a tolerable target as compared with the ports which the enemy are to single out for attack, and Drake's Island was worth a passing mention. Again, one of the 38-ton guns of Breakwater Fort would engage the port division, while the two 10-inch guns at Stamford would add their fire at extreme range.

Finally, the perfection which the position finding system has attained receives scant acknowledgement. "*Even* the 'blind firing' into 40-yard squares, which is used I believe in connection with the use of the Watkin position finders . . . . does not appear to render the rapid advance of the fleet much more risky." So far from being the refinement apparently indicated by the use of the word "even," this "blind firing" is now a thing of the past, and Major Watkin has enabled us not merely to direct and concentrate the fire of dispersed guns on a stationary vessel, but to hit a moving ship with equal ease, provided only that she steers a fairly straight course. Months ago, when this admirable system was roughly tried at Bovisand, a little towed target moving at eight knots was hit at 2500 yards, the fire being directed from the hill above.

Taking these various conditions into account, it will probably be admitted that the general immunity which appears to be claimed for the ships might not be entirely realized, even if we may not assume the use of field and quick-firing guns on Maker Heights which alone would effectually clear the tops and upper decks of the ironclads.

Coming now to the artillery performance of the ships themselves, it is difficult to avoid a feeling of profound scepticism. Naval director firing is a beautiful device under ideal conditions. "Everything is perfectly quiet except the ship, which is bowling along and gradually bringing the cross-wires of the telescope to bear on the selected embrasures." . . . "Perfect silence reigns in the ship, with each gun's crew lying down round its gun"—a charming picture sadly unlike the reality. These particular ships actually come under a heavy fire before they are abreast of Penlee Point. Picklecombe would be fairly swathed in its own smoke by the time the flag ship was ready to deliver its first broadside at a "selected" embrasure. Maker will be firing steadily down on the decks. Cawsand will be raking them with shrapnel. Has Captain Meryon made quite enough allowance for these slight disturbing agencies? The calculation of 45 hits on 10 embrasures in 90 rounds, which as he näively observes is "a sufficiently good allowance to enable us to deduct half of the hits . . . . and yet leave two hits on each casemate," appears to need considerable correction; though it is easy to concede that this number of hits so exactly distributed would be "sufficient surely . . . . to silence the guns." Picklecombe would, notwithstanding, retain an ample armament.

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As to the effects of the machine gun fire also, grave doubts arise. Other deductions from the Inchkeith experiments—equally "satisfactory," but from the opposite point of view—are possible; considering that on the first day 1541 machine gun rounds were fired under peace practice conditions with the result of killing one dummy. Had the *Sultan* herself been under fire, had the Inchkeith gun the benefit of a little smoke, or had the luckless dummy been able to move about, it is sufficiently clear that the result would have been *nil*. The crest of Fort Meks was 15 feet above the sea level; all the guns were packed close without a single traverse; five ironclads converged their fire upon the work, two of them devoting their undivided attention to it. Some 15,000 Nordenfelt, Gatling, and Martini bullets were expended in the action. Yet Meks was not silenced for about three and a-half hours, and Cawsand battery at 130 feet, as well as any field works on Maker Heights at 300 feet, might fairly count on tolerable immunity.

The above considerations lead to a very different estimate of the results of this imaginary action. But that all our torpedo boats have been "packed off" to the Mediterranean, we might claim an easy victory. As the ships turn their broadsides on Picklecombe and clothe themselves in smoke, torpedo boats lying behind the Breakwater will have the grandest of all possible opportunities. In two minutes they can be alongside, and it will need almost superhuman vigilance on the part of the enemy to stop them. Unless they can succeed under conditions such as these, torpedo boats are useless. No wonder their use by the defence is barred. In any case, the vessels of the port division will have their unarmoured or lightly armoured portions seriously damaged. Their auxiliary armaments will have been very roughly handled, their loss in men heavy. Under these circumstances, it may be that the Admiral will signal up his "powerful tugs" and "make off to sea as fast as possible;" while the defence will still have something to say to the tugs. In the heavy weather which must be supposed to prevail, the "cripples" may find themselves awkwardly situated.

While, however, Captain Meryon's data, in other hands, yield different results, his general deductions are rapidly reaching the "we always said so" stage of controversy. "With disappearing guns mounted singly all round the coasts of our large mercantile harbours, using the natural features of the ground to conceal their position, these places will be much more effective in the artillery defence than our fortresses." It is only to be hoped that the Clyde, the Mersey, and the Tyne, will before long possess such means of defence, and that the obvious anomaly pointed out by Captain Meryon will lead to a re-armament of our fortresses on rational principles.

The attack on Portsmouth is of a different nature. It is to be undertaken with deliberation and after careful preparation, including the fitting out of special ships. "A good moonlight night" is a desideratum, as a protection against the torpedo boats of the defence. The operations are of a systematic character and their success depends entirely on the destruction of the mine fields. It is proposed to notice briefly what appear to be the weak points in the solution of a problem

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which Captain Meryon is more than half inclined to consider as presenting "an almost insoluble difficulty." One of the first steps is the landing in Sandown Bay of a large party from the cruisers. The defence has, in this instance, full time for preparations, and the Isle of Wight would unquestionably have a strong garrison of Infantry with Field Artillery and guns of position. To land 1,500 men from the six cruisers would, under these circumstances, be a highly dangerous proceeding. "The protection of the guns of the fleet" could be relied upon only in a limited sense, and the invaders ought certainly to be driven back to sea with heavy loss—their re-embarkation might in fact mean disaster. The feasibility of such an operation under modern fire has yet to be demonstrated, and surprise is out of the question since "the small batteries and masonry fort in the Bay" have to be silenced. As night falls, preparations for creeping and sweeping are made and "a gunboat with electric light will be placed on the north of the Nab Shoal and another about 500 yards to the N.E. of her," throwing their beams "carefully on the Horse Fort." "This will give a triangle of great darkness between the two beams" in which the boats are to work. The darkness however will be sensibly modified by the electric lights of the defence, and heavy shrapnel from the forts should prove extremely annoying to the sweeping and creeping boats, notwithstanding that the range may not be accurately known. It may also be doubted whether all the vigilance of the torpedo catchers will prevent the torpedo boats of the defence from closing with the moored gunboats; in which case the latter would probably disappear altogether from the scene. Captain Meryon admits that the disorder which would result, even from a repulsed counter-attack, would be fatal to the creeping.

Daylight having apparently arrived, six or eight gunboats attack St. Helens Fort "steaming slowly towards it," turning, going back and so on. They are so small that they will not be "easily hit." The attack selects individual ports to fire at, and hits them; but the defence can hardly hope to hit a gunboat, though the relative targets are about as a stag to a medium haystack!

One or two howitzer flats are now towed into position in the shallow water to the north of Bembridge, whence they can fire on any "masked earthworks which may commence to attack the fleet from the direction of Ryde and Nettlestone." Howitzer fire directed in salvoes by a position-finder will prove a source of considerable danger to vessels anchored or in slow movement. Used from a ship it would be effective in bombarding a town. As against a "masked earthwork," its value is simply *nil*. The dangerous area in a properly designed coast battery has far too little *depth* to make it a suitable target for howitzers afloat; and under most circumstances the howitzer vessel will be unable to obtain ranges with sufficient accuracy. As might have been expected, the experiments carried out by H.M.S. *Hercules* at Shoeburyness afford no evidence whatever of the value of howitzer fire from ships. On the other hand, these "howitzer flats" will be fairly satisfactory targets for howitzers on shore.

Meanwhile, the main attack, directed on Horse Sand Fort keeping

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Spitbank in line and therefore blinded, is in progress. This attack is most skilfully planned; but is nevertheless liable to be easily deranged, The object is, by frame ships and countermining, to cut a broad channel leading through the interval space between No Man's and Horse Sand Forts. The actual position of the mine fields is not known with certainty, and failing positive information the whole operation must be carried out on the principle of systematic approach. The frame ships lead and the iron-clads follow. On reaching the position cleared and buoyed on the previous night, the frame ships drop to the rear and "one of the thinnest armoured ships" moves up, and anchoring with a spring, brings her broadside diagonally to bear on Horse Sand Fort. All the other ships open fire as best they may on No Man's Fort. Two lines of countermines are now run by gunboats towing launches, clearing a channel 700 yards towards Horse Sand Fort. The rear ironclads move up at once. The leading vessel engages Horse Sand Fort as before. This process is continued till the ship is 1200 yards from Horse Sand Fort. Assuming the operations to have commenced 5000 yards from the latter fort, five double sets of countermines will have to be run to reach this point. Here a "bombarding station" is established for the attack of Gilkicker and the open earthworks on Southsea Common. Since these positions are 7500 and 5000 yards distant respectively, and the first is bomb-proof, except as regards a few guns perched upon the top, they will have extremely little to fear from a ship's howitzer fire. Countermining, followed up by the advance of the ironclads, singly or lashed together, is continued till the ships are "a considerable distance past the passage" between No Man's and Horse Sand Forts—entailing, say, three more double runs.

The game is now nearly played out, and the forts are to be boarded if need be along the yards of the masted cruisers, an operation obviously implying their previous evacuation or practical ruin. Everything, in this method of attack, thus depends on the success with which some eight double series of countermines are run. There is no mention of any probable naval defence on the part of the fortress during this stage of the proceedings. The gunboats of the defence, however, would take up positions on the right flank of the attack north of the Horse Tail Sand, and being very "small and of light draught would probably not be easily hit or blown up." Their fire would be excessively inconvenient to the countermining boats, and they should be able at least to harass the ironclads which singly engage Horse Sand Fort during the first part of the advance. The arrival of this great fleet off the Isle of Wight, and the attack on Sandown battery on the previous day will bring up some British ironclads from Portland or Plymouth, which arriving at Spithead by the Needles Channel will take a rather active part in the proceedings. The torpedo boats of the defence would also find their opportunies, lying behind the two island forts or hovering round the flank of the attack. These various possible disturbing agencies appear to deserve mention; since their effect cannot be exactly foreseen or provided against and lends itself less easily than the mere artillery fire of the forts to the pre-cal-

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culation of the enemy's Commander-in-Chief. By practically depriving the defence of all initiative, except the establishing of siege guns near Nettlestone Point, Captain Meryon vastly simplifies his problem. Something must, however, be conceded to the unforeseen, and in a plan of attack of this nature requiring the precision of a review manœuvre, very little would suffice to bring about hopeless derangement.

The whole operation of countermining, on which success in this case hinges, appears to be speculative in the extreme. The French have not even adopted this method of attack up to the present time. Thoroughly worked out and admirably executed as it is by our Navy, countermining possesses a natural fascination. Opportunities may occur for its practical application in war—few things are absolutely impossible to brave men—but recent experiments have conclusively shown that a moderate fire is sufficient to cut countermining gear to pieces. Even a rifle bullet will sever the cable and render a whole equipment useless, till a splice can be effected. Special boats may possibly be designed to give protection to the gear; but it is hardly too much to say that "old wooden launches" which can be seen and fired at by quick-firing guns, machine guns, shrapnel or rifles are effaced. These particular countermining operations, carried out in broad daylight, will, therefore, involve a far more complete artillery preparation than Captain Meryon provides; even if the defence is deprived of all floating armament, and if the siege or field guns in the Isle of Wight are completely obliterated by the "cruisers, gunboats and howitzer flats" which have succeeded in silencing St. Helen's Fort.

In thus directing attention to what, in a landsman's view, appear to be the weak points in Captain Meryon's most instructive lectures, it has been sought to present the other aspect of the question. No one would be found to maintain for a moment that the defences of either of the great ports in question are satisfactory. Few now dispute the general principles which Captain Meryon advocates as to the disposition of artillery defence. The strength and security of the country is our common object, and frank discussion is the surest road to its scientific attainment.

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REMARKS

ON

HIGH-ANGLE AND DIRECT FIRE

FROM

COAST BATTERIES.

BY

COLONEL G. A. CRAWFORD, LATE R.A.

In the problem of guns *versus* armour-plates during the last 20 years, it must be admitted that the gun has won the day; but there seems to be a tendency in some minds to desert the royal road of Direct Fire, and to fall back on the remote contingency of High-Angle Fire, for the off-chance of hitting a ship's deck. This I am convinced is an egregious mistake, and if our coast batteries are to be armed with howitzers, as is advocated by some officers, our artillerymen, who have to fight our forts in war time, will find themselves armed with an ineffective weapon, which will only give harmless hits once or twice in a hundred shots, whereas the gun should give 60 or 70 per cent. at least of vital blows.

Extract from page 21, Inspector-General of Fortification's pamphlet on Coast Defences, March, 1884, states :—"Since it is now tolerably certain that ships will have to anchor, or come back to a given point to fire when seriously engaging earth batteries, the employment of curved fire against them will sooner or later find favour. The fact that with an 11-in. howitzer at 7300 yards, five shots out of ten were placed on a target representing the deck of the *Inflexible* (*Journal, R.U.S. Institution*, 27th January, 1882), is sufficiently significant. The heaviest ironclads are exposed to this attack on the deck by means of curved fire, and the moral effect of this fire delivered from small groups of heavy howitzers will probably suffice to prevent them from anchoring or even manœuvring at slow speed within range."

Again, Memo. on Coast Defences, W.O., 16th October, 1884, states :—

High-angle fire from heavy rifled howitzers will also be effective against ships at anchor at long ranges, and although the chances of hitting ships in motion by such fire may be small, it will nevertheless be very annoying and disturbing to them, particularly since it cannot be effectually silenced. The experiences of Alexandria go far to show

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that in order to deliver a really effective fire, it is necessary for the ship to anchor or to come back to known ranges. To prevent anchoring will therefore in such cases be an important object, and this can be obtained by high-angle fire.

In Colonel Shaw's lecture on Coast Defences, 8th December, 1886, R.U.S. Institution :—

For the abovementioned reasons, he advocates the use of the howitzers in our coast batteries. In these extracts, the first reason assigned for employing high-angle fire against modern ships of war is to *prevent them from anchoring* because the ship cannot hit the fort when on the move, and the action of our fleet at Alexandria is quoted as an example. Now, the conditions of the fight at Alexandria were not at all equal, and it can hardly be taken as an instance of a modern ship *versus* fort action. The latest example we have where the guns and gunners of fort and ship were on equal terms was at Charleston (*see* Boynton's History of the American Navy); buoys were laid down at known ranges, and as the monitors came up to them a concentrated fire was brought to bear on them, and the result was they were all beaten off or destroyed.

The Egyptians at Alexandria had a weak armament; their gunners can hardly be called skilled artillerymen, they had no range-finders to find the range, a *sine quâ non* in the present day, hence the damage done to our fleet was very trifling. The lesson we have to learn from Alexandria is the necessity for having a good armament of *armour-piercing* guns and *well-trained* gunners to man our coast batteries.

A fort has so much advantage over a ship that, taking the power of hitting of ship and fort as equal, the fort should invariably win the day. The fort cannot be sunk, it has no boilers to burst or steering gear to get out of order, it cannot be rammed either by friend or foe, it is safe from torpedoes and submarine mines, a ship's range can easily be determined from it, besides it has the incalculable advantage of having a stationary platform to fire from.

If the fort can hit as hard as the ship can, why should the fort commander endeavour to prevent the ships from anchoring? Surely nothing could be more satisfactory to him than for the attacking fleet to anchor within range of his guns; a carefully measured range and a concentrated fire on to each ship in succession ought soon to make it the last anchoring place of each one of them; it is unnecessary therefore to arm our coast batteries with howitzers to prevent ships from anchoring.

The extracts quoted allow that the chances of hitting ships in motion are small by high-angle fire, so that if the enemy's ship does not elect to anchor, the groups of howitzers with their gun detachments are useless, for as percussion fuzes must be used, unless the ship is struck the shells will not burst, their annoying and disturbing effect therefore will be of the smallest nature; and even if time-fuzes are employed, as shell protection is provided for all hands on board a modern ironclad, the moral effect of this fire will be reduced to a minimum. But then comes the question,—Will an enemy's ship be rash enough to anchor within range of the fort's guns? I have consulted several distinguished

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naval officers on this point and they are all agreed that the last thing they would do would be to anchor when engaging forts—one says "I should certainly keep under weigh, moving at as high a speed as practicable, and I should regard it as a great disadvantage having to anchor." It is true our fleet did anchor at Alexandria, but I imagine the result of the action would hardly have been so successful in the face of guns and gunners of any other nationality besides the Egyptians.

The second reason assigned for the use of howitzers against ships of war is on account of the accuracy of their fire at long ranges. At 7300 yards an 11-in. howitzer having placed five shots out of ten on a target representing the deck of the *Inflexible*.

I have had some experience in howitzers, as 8-in. and 6·6-in. howitzers were sent out for the armament of Hong-Kong during the recent war scares, and although I am unacquainted with the 11-in. howitzer, I can hardly credit this arm with such extraordinary power either of range or accuracy of fire as is claimed for it, and Colonel Baylay's report on breeching experiments at Lydd seem to confirm this opinion.

Vol. XIV. Proceedings, R.A. Institution, September, 1886, page 562, states :—

High-angle common shell fire for searching effect from batteries of the 1st and 2nd Artillery positions (2400 and 1600 yards) :—

" . . . . At the termination of the series, it was fairly evident that even under the most favourable conditions, no large measure of success would be likely to attend the employment of fire of this nature, even from the most accurate of our siege train howitzers."

This is the result of our 8-in. and 6·6-in. howitzer's practice at less than one-third and one-fourth the range (7300 yards) at which the 11-in. howitzer quoted is stated to have been fired.

Again, page 565. "Range 2400 yards. The 8-in. howitzer of 70 cwt., struck the magazine *six* times in 20 rounds = 30 per cent. The 8-in. howitzer of 46 cwt., struck the blindage *four* times in 30 rounds = 13 per cent. The 6·6-in. howitzer struck the magazine *eleven* times in 30 rounds = 36½ per cent. Inaccuracy of high-angle howitzer fire in squally weather. Besides the above, the 8-in. howitzer of 70 cwt. fired 10 rounds at the magazine *without* hitting it; this practice was carried out in a bad light and under unfavourable atmospheric conditions." (N.B.—They might be the conditions of war). The total number of hits at 2400 yards is therefore 79½ in 310 rounds, *i.e.*, about 26 per cent. with a carefully measured range and under peace conditions, and although the area fired at, two field magazines, which appeared to be 44 ft. × 30 ft., is not so large as the deck of the *Inflexible*, we can hardly claim for our howitzers the range and accuracy of the 11-in. howitzers alluded to; and I think we may fairly argue that if one or two per cent. struck a ship's deck in war time, it would be as much as we could expect.

We have also to consider that even in the event of a hit, whether a howitzer shell with its low velocity (almost the force of gravity only at long ranges) will penetrate a ship's 3-in. or 4-in. steel deck.

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Percussion fuzes must of course be used. There have been no experiments that I am aware of to solve this question, but my idea is that an unburst shell will not penetrate, and if it did, it would be a casualty.

Then, again, will not the shell burst before penetration?—on impact. I remember in breaching the walls of Kandahar with 40-pr. B.L. guns, these walls were composed of homogeneous mud (dried), and discovering when experimenting for penetration that unfuzed shells (filled) burst on impact against these mud walls. I fired over 60 rounds of unfuzed shells to complete the breach, and all without exception burst, and I am inclined to think that howitzer shells will burst before they have passed through a ship's deck.

I think we may conclude that to fire high-angle shells at a modern ironclad, will be a thorough waste of ammunition as well as a waste of *personnel* in employing gunners to man them in our coast batteries. On the other hand, if ships of war attacking earth forts were armed with a complement of howitzers, their high-angle fire against elevated forts would be very annoying and disturbing both to the forts and to the gun detachments, in fact it is the only sort of artillery fire that could touch the fort. Howitzers therefore might be suitable weapons for our ships.

The only time a shell-fire is required from the fort is in the event of "all hands on deck" or when the ship's crews take to their boats to storm, and then the high velocity gun shrapnel, with time fuzes, would be infinitely more effective than any low velocity howitzer shell.

Direct Fire.

The proper weapons for our modern coast batteries are *guns, heavy, medium, quick-firing, and machine guns*, and the projectiles to be fired from them are *armour-piercing, shrapnel*, and *case*; the proportion being—

65 per cent. armour-piercing.
20 " shrapnel.
15 " case.

Since the introduction of our new B.L. guns, the range for piercing armour has increased to 4000 yards, and even longer when firing at thinly clad ships, and the scattered gun system, with guns mounted at elevations of two, three, four, or even five hundred feet above the sea gives the fort numerous advantages both in attack and defence. The ship becomes much longer under fire. A concentrated fire can be brought to bear on it. A deck fire from elevated sites is obtained. And for defence, the greater the altitude of the fort, the safer it is from a ship's fire.

In harbour defence, we may safely conclude that an enemy's ship will not attempt to anchor, so that the target we shall have to fire at will always be a moving target; hitherto moving target practice has been simply a casual experiment, and our gunners have had no regular course of training at firing at a moving target, the nearest approach we can get to a ship under weigh; one or two ludicrous occurrences

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have happened consequently which have given an idea that the practice is somewhat dangerous, but when men are well trained in laying on moving targets, there is no more danger in the practice than in firing at a stationary target.

My first experience at moving target practice was at Bermuda some fifteen years ago where the target was moved by tide and wind, and the practice was carried out with 20-pr. B.L. guns; but in those days we had no range-finder, and the results consequently were not very satisfactory; and during the last five years I have had some experience at this practice in China both with the Royal and Volunteer Artillery, and with the aid of Watkin's Depression Range-Finder, and that invaluable instrument has given the gun three or four-fold the power of striking than it had previously. I have come to the conclusion that with well-trained gunners it is as easy to hit a ship in motion as a ship at anchor.

The target we used was constructed by Captain H. Bunbury, R.A.; it consisted of a plain board as a *keel* and a 6-ft. × 6-ft. canvas target; black with white bull's eyes placed on top of it, two out-riggers like a Cingalese boat, one on either side attached by iron staunchions and towed by a launch with a 100 yards line. The target is started off at about 1000 yards range at 8, 10 (or 20 knots if you can get it), and moves obliquely across the range up to 2500 or 3000 yards—with B.L. guns of course it could be longer. The range finding officer calls out the range at every hundred yards or so. Each No. 1 is given three rounds, and he fires these three rounds at the moving target consecutively as quickly as he can. The rule he uses for deflection is multiply the rate in knots by five, and it is quite accurate enough up to 10 knots, the highest speed I could get; six might be the factor for a torpedo launch of 18 or 20 knots. Having laid on the target at a little more or less of range according as the target is moving away or towards him, he trains his gun a little ahead, retires to rear of platform, and when the target is in line with his sights he fires, and jumps down and proceeds with the loading for the next round.

The best shot I have seen at this practice giving an 80 yds. × 4 yds. rectangle instead of a 40 yds. × 2, the regulation rectangle for a stationary target, scored 10·10 for two shots at a standing target and 10, 15, 8, for three shots at the moving target, the hit being through part of the bull's-eye.

At the bi-weekly gun drills, the moving target was towed in all directions in front of the battery, and the men practiced in laying on it, and the chances of accident through ignorance and inexperience was reduced to a minimum. As only a few rounds from guns of a heavy nature could be expended, this practice was carried out from 64-prs. and also 7-prs. as well as 9-in. M.L. guns. It assimilates to war conditions and teaches the gunner his most important duty, viz., to hit—and a little practice soon eliminates the fuss and flurry so inimical to accurary and so conducive to accidents, and proves the truth of the old adage that "practice makes perfect."

Our M.L. deflection scales seem to have been constructed to give so many inches of error on a stationary target due to wind action on the

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projectile, whereas they should read to 2° at least on either side of the zero, to give sufficient deflection allowance for a ship moving at speed, this has been done with our B.L. deflection scales.

Again, it is preferable for the No. 1 to fire; No. 5 can make ready and hand the end of the lanyard to No. 1, who retires to the end of the platform to look over his sights to the last; he requires a step in rear to assist in jumping down, although I have seen a No. 1 remain on the wooden stage in rear and not jump down at all; as recoil by late improvements is now so well under control, arrangements can easily be made for the No. 1 to look over his sights to the last and get clear of the gun. The No. 1 should be left entirely to his own resources, he has plenty to think about and should be left undistracted.

After a preliminary course of laying on moving targets with the aid of the range-finder, when every man learnt exactly what he had to do, the shot at practice were pitched as close to the moving target as at the stationary target practice, and all thought of danger to the launch with a 100 yards tow line soon vanished; when a target turned about it was necessary sometimes to remind the No. 1 to change his deflection from right to left, but even if he had forgotten to do so, the shot would strike farther from the launch instead of closer to it.

The ultimate test of the garrison gunner's efficiency should be his capacity for firing three or more consecutive rounds at a moving target in as short a space of time as possible. Our prizes for skill-at-arms might be given for this war condition of shooting, and the stationary target practice used as a stepping stone to it.

The range-finder should be in charge of men capable of keeping them in adjustment and thorough working order and able to place new cross wires in them when required, a man conversant with a theodolite will soon acquire this knowledge.

The N.C. officers and men require a thorough course of training both by lectures and drills, diagrams showing the course of a ship receding from or coming towards the battery directly and obliquely, and how elevation and depression should be given accordingly.

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A MACHINE GUN BATTERY IN BURMA.

BY

CAPTAIN W. N. LLOYD, R.A.

Commanding Gardner Gun Battery.

THE subject of machine guns has of late been so much under the consideration of both our Naval and Military authorities, that I feel it will be a matter of general interest to describe the organization and equipment of the four-gun Gardner Battery, raised for service in this country.

An interesting article entitled "Proposal for a Machine Gun Battery," by Lieut. G. E. Benson, R.A., was published in the Institution papers last year. In this article Lieut. Benson dealt with the organization of a Machine Gun Battery on Field Artillery principles, and both the detail and information, which he gave on the subject, would have proved of value to anyone ordered to raise a battery on this particular system; but unfortunately, in Burma, we were unable to benefit by his suggestions. Wheeled transport in this country is out of the question; the so-called roads are mere jungle paths, while the jungle itself is dense, and practically impenetrable. Therefore when the O.C. R.A. in Burma (Colonel Carey) ordered me to organize and equip four Gardner guns for immediate service, it was at once decided that mule transport must be utilized.

The guns handed over to me were the 0·45-inch two-barrel Gardner, with Martini-Henry chamber, and were originally intended for the Naval Brigade. It appeared at first, as a glance at the plate will suggest, that we had a difficult task to perform, for the whole construction looked eminently unsuitable for mule transport. On investigating the mechanism, however, difficulties disappeared, as I will endeavour to explain.

The barrels of the gun are fixed in a gun-metal casing, the top of the casing being closed in by the cover (A) which is pivoted to the fore end of the breech casing and is locked down by the cascable screw (D). In the breech casing are the locks which carry the mechanism for igniting the cartridges and extracting empty cartridges, the locks being driven backward and forward by working the handle (F).

The gun is fed from a vertical cartridge feeder (G), which can be detached; it holds 30 cartridges and is supplied while firing from wooden cartridge holders carried in the ammunition boxes.

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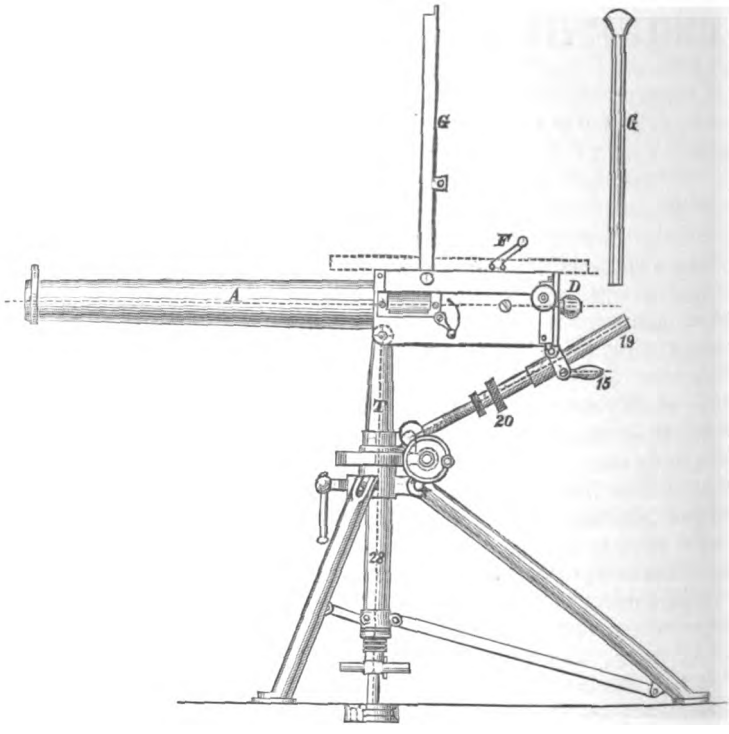
There are two sights, a fore and a tangent sight, the extreme range being 2000 yards. The gun is mounted on a tripod, the axis of the piece being 2 ft. 9·75 inches from the ground. The arm (T) which is attached to the gun and can be folded up under it (a fact of great importance) drops into the socket (28) of the tripod.



For rapid elevation or depression the hand nut (15) of the brake is released, when the handle (19) will be free to slide in the sleeve (16). When laying the gun on an object the hand nut is tightened and the adjusting nut (20) turned to give the required elevation or depression.

The weight of the gun is	...	...	131 lbs.
" " " tripod	...	...	61 "
Total weight	...	...	192 lbs.

We now borrowed two mules provided with the mountain battery gun and ammunition saddles, and found that by altering the cradle of the gun saddle to receive the square breech case, that the Gardner gun could be carried with the greatest facility, while the tripod was easily strapped on top of the ammunition saddle (which has now been altered to receive the legs) on which were also carried two boxes of ammunition, each containing 360 rounds.

Having thus mounted the gun and ammunition boxes, we tested, roughly, the rapidity with which the piece could be brought into

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action from the mules backs; a matter of the greatest importance in any campaign, but especially so in this country. With five gunners, three to the gun and two to the tripod, the time was 16 secs., which was most satisfactory. Our next object was to discover if the tripod would remain steady under rapid firing, without requiring the feet to be fixed to the ground—a performance which would take time and thereby diminish the efficiency of the gun—and also to note what "jams" might occur. We fired 400 rounds, sometimes very rapidly; there was no recoil, the feet of the tripod remained steady and no jam was noted. Having thus satisfied ourselves that we had a good weapon in our hands we set to work to equip a battery of four guns.

I will not take up valuable space by narrating the many difficulties which presented themselves—in a place where no equipment or stores exist, these difficulties may be readily imagined. Suffice to say that we scraped our equipment together "anyhow" and that a battery turned out efficient and fit for service, the establishment of which I now propose to give in detail both as it is, and as it should be. I would, however, point out the reasons which cause our present establishment to be incomplete:—

Firstly, on account of the paucity, through sickness, of officers, N-C.O.'s, and men, R.A., in the command, the battery is undermanned.

Mules are also scarce, therefore we have not one full complement; and again, as regards the small supply of ammunition which accompanies the battery, we have been obliged to take into consideration the fighting qualities of the enemy to whom we are opposed.

Dacoits seldom offer a stubborn resistance; the fights are of short duration, lasting generally for about half an hour. Consequently there is no necessity for dragging a large supply of ammunition about the country, thereby lengthening a column unnecessarily. It will, therefore, be understood why the allowance per gun of ammunition is so small compared with that which would be requisite if the battery were engaged in a campaign elsewhere.

INDIAN ESTABLISHMENT FOR A GARDNER GUN BATTERY OF FOUR GUNS, WITH MULE TRANSPORT.

OFFICERS AND MEN—EUROPEANS.

	Present Establishment	Establishment recommended.
Captain	1	1
Subalterns	1	2
Sergt.-Major	—	1
Qr.-Mr.-Sergt. ...	—	1
Sergeants	2	4
Corporals	—	4
Bombardiers	3	4
Gunners	21	28
Trumpeters	—	2
Total	28	47

50

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ARTIFICERS.

Farrier ...	...	—	...	1
Shoeing-Smith	...	—	...	1
Collar-Maker ...	...	—	...	1
Wheeler ...	...	—	...	1
Armourer (a skilled workman)		—	...	1
Grand total	...	28	...	52

HORSES.

Officers ...	...	4	...	4

NATIVES.

Gemmedar ...	...	—	...	1
Duffadars ...	...	2	...	4
Drivers ...	...	25	...	50

ARTIFICERS.

Smith	...	—	...	1
Carpenter ...	...	—	...	1
Collar-Maker ...	...	2	...	2
Bhestie, sweepers, cooks, &c.,	...	3	...	8
Grand total	...	32		67

AMMUNITION.

On tripod mule (per gun) ...	720 rounds	720 rounds
Spare ammunition (per gun)	1160 „	1160 „
1st Reserve ammunition (per gun)	1160 „	3480 „
2nd Reserve ammunition (per gun)	1160 „	4640 „
Total rounds per gun ...	4200 „	10,000 „
Total amount of ammunition for the battery ...	16,800 „	40,000 „

(*Transport not included.*)

It will thus be noticed that the establishment of a four-gun machine battery is about half that required for a four-gun mountain battery; which is a most important fact when comparing their relative expense and value.

I will now point out the advantages of a machine gun battery in this particular campaign. The favourite tactics of the dacoits is, as I said before, to lay an ambush in dense jungle, where they are at home

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and comparatively safe; they then fire a volley into our unsuspecting troops and decamp, having inflicted a loss amounting perhaps to six or seven men killed and wounded. With such tactics we cannot cope, as it is impossible to throw out flankers in the dense jungle; we, of course, return their fire but with little effect; in this case therefore machine guns would probably prove as useless as the other arms of the service.

When, however, the dacoits oppose our advance by clinging to the jungle in our front, their position, never extensive, would be quickly searched out by machine guns. Again, their value would be appreciated in storming stockades, some of which are bullet proof, others not. In the latter case the guns having a range of 2000 yards could keep up a stream of bullets (provided the country admitted of it) out of the enemy's fire. While in the former case, the stockade having been sufficiently pounded by artillery fire to enable our men to rush it, machine guns would take up a position bearing on the line of the enemy's retreat. In like manner they would be utilized in the attack on dacoit villages. For passive defence the Gardner guns might be employed in our military posts, which have in several instances been hard pressed by dacoits. Moreover, the power of these guns for counter attack as well as for passive defence cannot fail to be recognized.

With regard to the Gardner gun, Captain Colomb, R.N., in an article on machine guns says "Mr Gardner's aim has never been to make a powerful gun. It has rather been to establish a minimum of weight and space in the first instance, and within that limit to achieve the greatest possible rapidity of fire. He does not apparently rival the other competitors for favour, but took up ground which they had left unoccupied. With the larger and more powerful weapons there are difficulties of transport and of placing and training. Where such difficulties occur Mr. Gardner appears to say 'give up some of your power, and accept a handier, lighter, and smaller weapon.'"

These remarks of course apply to land service especially, where mobility is so essential. The 0·45-inch two barrel Gardner gun is extremely light, and mounted on mules' backs could travel over any country. For example, the load of the gun mule is, in our battery:—Gun, 131 lbs. + saddle, 73 lbs. = 204 lbs. And of the tripod and ammunition mule:—tripod, 61 lbs. + ammunition, 138 lbs. + saddle, 83 lbs. = 282 lbs.

The load of the gun and ammunition mules respectively in a mountain battery being:—

Gun mule	...	...	...	290 lbs.
Ammunition	...	...	...	353 ,,

Therefore whether the gun be mounted on mules backs or light carriages its mobility alone renders it efficient.

Captain Colomb justly remarks that "the era of the machine gun is at hand for the English army." Let us hope it is. At the present moment the machine gun, is as it were, "nobody's child." The

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gunner has hitherto contended that its advantages are not sufficiently important to justify its substitution for the field gun. With the cavalry it has recently been tested, but the result has as yet not reached us, while the infantry soldier prefers his rifle; and notwithstanding these objections, it seems to be the general opinion of officers of experience in each arm that machine guns should have a place in our army.

In the Navy the gun has firmly established itself, it is in the army alone that its advance hesitates.

Let us then look forward to the machine gun being given at any rate a fair trial.

MANDALAY,
28th November, 1886.

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THE

FRENCH TROOPS IN ALGERIA.

BY

CAPTAIN E. LAMBART, R.A.

DURING a recent visit to Algeria, I had some opportunities of seeing the French troops there, thanks to the courtesy of the General Commanding the Algiers Division of the 19th Army Corps, and the following notes may be of interest:—

Artillery.—The Artillery arm, of which I saw very little, does not seem to be largely represented in Algeria. I understood that in the whole province there were only six Field batteries, two Mountain batteries (one of which is at present employed in Tonquin), and a few Garrison batteries in forts at Algiers and other points on the coast. There is a Field battery in Algiers, but through some misunderstanding, I did not have an opportunity of seeing it in detail. The Artillery officer who shewed me round commanded a Garrison battery and kindly shewed me his Quarter-master's store and his barrack-rooms which were admirably neat. A great feature of French equipment is the pocket handkerchief, elaborately illustrated with pictures of the arms, drills, &c., of each branch, with printed instructions on a variety of points connected with the soldier's duties. They are spread over the kits on the shelves in the barrack-rooms. The Garrison Artillery rmed as are a with us, with carbines and sword bayonets.

Infantry.—I saw the barracks of the Zouaves at Algiers and the *Tirailleurs Indigénes*, commonly called *Turcos*, at Blidah, a garrison town fifty miles in the interior. The Zouaves, who seem quite the pick of the French Infantry, are recruited from the French population in Algeria with a few men from France. The officers are appointed in the ordinary way from the Military College of St. Cyr. The uniform consists of baggy trousers supported by a "kummer-bund" and a loose jacket, giving complete freedom to the arms, low shoes and white gaiters like our Highlanders. The head dress is a fez, worn with great ingenuity on the very back of the head, which is supplemented on all duties by a narrow tightly folded white turban. The men are of very fine physique, march well, and are admirably drilled.

The bayonet exercise does not consist as with us, of a number of methodical movements on a stiff pivot, but the men are taught to charge a few paces in each direction and then to execute a *volteface*

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with great alacrity, followed by a sort of "double attack" in the new direction. The effect of a whole battalion practising this is very curious. The whole training is most elaborate. In addition to the ordinary drills every man is taught fencing in the *salle d'armes*, gymnastics, including running in marching order, and leaping a number of obstacles, and *le boxe*, not quite *à l'Anglaise*.

The discipline is very strict, and requires to be so, for the Zouaves are very unruly. I was told by an officer of the regiment that the *salle de police* contained sometimes over a hundred prisoners. Judging by the number of men I saw at defaulter's drill I can well believe it. This last is not as with us, wasted in marching up and down with kits on the men's backs, but is turned to good account by instruction in the various drills and by making the defaulters cover a certain distance in marching order, partly at a smart double. The interior arrangements of the barracks seemed admirable. The barrack-rooms are large and well ventilated and the beds much more comfortable than those we give our men. The food also seemed a great improvement on ours, as there is a different dietary for every day, and the natural culinary talent of the French turns the materials to much better account. The Zouaves are armed like the rest of the French Infantry, with the "Gras" rifle, a modification of the old Chassepôt. The action seems very simple, as several men taken at hap-hazard took their rifles completely to pieces and put them together in a very few minutes. The bayonet is several inches shorter than ours and quite straight. I did not see any repeating rifles but was told they were ready in store. I was much struck by the great bulk and apparent weight of the kit carried by the Zouaves on their backs in marching order. In addition to the knapsack, greatcoat, mess-tin, and ammunition, each soldier carries a portion of a *tente d'abri*, and camp cooking-pots, giving them the appearance of organ-grinders carrying their instruments. For service under a tropical sun in the desert the load must be very heavy even for such fine men as the Zouaves undoubtedly are, but I was assured that the same weight was carried on service in the interior, and that very few of the men fell out on the march. The careful and very severe physical training the men are subjected to may have something to say to this, but I am sure none of our regiments could march and fight under such a load, and it is difficult to believe the little *piou-piou*, or ordinary French linesman, could get along with it.

The men mess by companies in rooms set apart for the purpose, and have also a canteen very much like ours. Wine takes the place of beer, and spirits are prohibited.

In each barrack there is eventually to be what is called a *salle d'honneur*, to contain the records of the regiment, its battles, names of commanding officers, and men who have distinguished themselves, &c., &c. This is an idea of General Boulanger's to encourage *esprit de corps*, and the State presents each regiment with pictures of any battle in which it has been particularly distinguished. Any officers and men with artistic talent are invited to assist in decorating the room, which will be open to all ranks.

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The *Turcos* are mostly Arabs with a small proportion of French soldiers who have completed their compulsory service and are allowed to re-engage for these regiments. There seemed also to be a good many of what are called in the native regiments in India "line-boys." The uniform is the same as the Zouaves in shape but the colours are different, blue and yellow. They are broken up into detachments in different frontier stations, and one battalion is in Tonquin at present. The depôt is at Blidah where there are about 300 men. They are a fine hardy lot of men and march with a wonderful *élan*. The band contains a number of native musical instruments, including a sort of bagpipe, and the music sounds very wild and quaint. The French officers think a great deal of them as fighting men, but I was told they could not be taught to shoot well, a weak point I believe with our Native regiments. They have Native officers and a proportion of European officers as well. They are equipped in every way the same as the other French regiments and are housed in regular barracks with beds, &c. The food is slightly different to suit the native taste, but the cooking, messing, and canteen arrangements are the same.

The obstacles I referred to above, which the men are made to clear in heavy marching order, are really formidable. I saw a sort of steeplechase course laid out round the parade ground of the *Turcos* which included a 6-ft. wide jump, a water jump with a drop of at least 3-ft., and a revetted ditch 6-ft. deep. It says a great deal for the physical training of the men that they should be able to clear these with a knapsack, &c., on their backs and a rifle in their hands.

Cavalry.—I saw the famous *Chasseurs d'Afrique* at Blidah (1st Regiment). It was impossible to help thinking that they were terribly undermounted. The horses (nearly all greys) are a mixture of Arabs, barbs, and crosses between the two breeds with a touch of English blood, which I will explain in speaking of the Remount Establishment at Blidah. The average height I should say was certainly not more than 14·2, and the men are about the build of our Hussars. They are all Frenchmen. The uniform would be very smart if better made. It consists of a light blue tunic with black Hussar braiding, the terrible baggy crimson overalls, universal with French mounted troops, and a sort of cap-shako with a "pompon" for full dress. For service in the desert a white flap is attached to the cap behind, similar to that formerly in use in India. The equipment consists of the "Gras" carbine worn over the shoulder (there is also a bucket on the saddle) and a long almost straight sabre suspended by a single sling.

The saddle has web girths, and no surcingle. The regiment I saw had two patterns, one with no panels with a numnah and a folded blanket underneath, and the other with leather panels stuffed with horse hair. This last is the new pattern, and the French officers seem to think it very satisfactory. With this saddle the numnah is not used but only the folded blanket. The blanket is of course used to cover the horse at night in camp, and seemed rather thin for the

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purpose. There are two shoe-pockets similar to our own and carried in the same way. The crupper has lately been abolished. The breast-plate has no chest strap. The headstall is very light and simple, and carries both bridoon and bit. The latter can be easily detached leaving the bridoon for use at exercise or watering order. On the other hand there is a heavy neck strap which is put on in marching order which carries the head rope, and not being attached to the head-collar rubs the mane a good deal. The cloak is attached in an enormous roll to the saddle in front, and a sort of double saddle bag made of canvas fits over the cantle and rests of the horns of the saddle.

With the exception of the head collar with its simpler bit attachment, I did not see any point in the equipment of the the *Chasseurs d'Afrique* which was an improvement on our own, and I doubt if they ride any lighter than our own light cavalry. The horses are shod with a very broad web shoe with, I think, eight nails. They are all stallions. The officers ride in a saddle almost exactly the same as our Hussar pattern except that the wallets are of the folding pattern. The forage is of very poor quality, but Arabs can eat anything and the little horses looked in capital condition.

The Spahis or Native Cavalry are detached in squadrons about the Cavalry, and I did not see any but a few orderlies, &c. They ride in a marvellous native saddle with a cantle like a chair back, and shovel stirrups. They are very picturesque looking and excellent riders, but I was told by a staff officer that they were not nearly so good as they used to be.

The frontier tribes have quieted down and do not give such constant employment to the troops, and the Spahis no doubt have deteriorated for want of work, but they look excellent material for Native Cavalry.

The Remount Establishment at Blidah supplies the whole of the horses for the mounted services in Algeria, including officer's chargers (which are State property) and sends a good many remounts to France as well. I had not time to see it very thoroughly, and most of the stallions had just been sent out into the province. They are lent to the farmers to cover their mares, and the State has a prior claim on the produce. I saw about 20 in the stables at Blidah, Arabs, barbs, and what they call Anglo-Arabs, the produce of thorough-bred English mares and Arab stallions. There was also a good-looking Turcoman which had been sent over from France as an experiment. Some of the Arabs were really high caste animals, beautifully shaped, but the barbs were mere ponies. I was told that they had hardly any pure Arab mares as the natives cannot be induced to part with them, and I had no opportunity of seeing any of the mares in the possession of the farmers. The remounts are put into the ranks at three years old.

DUBLIN, *April*, 1887.

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ABSTRACT OF THE PROCEEDINGS

OF THE

FIFTIETH ANNUAL GENERAL MEETING

OF THE

ROYAL ARTILLERY INSTITUTION.

The 50th Annual General Meeting was held in the Theatre of the Institution on the 16th May, 1887. Maj.-General G. Le M. Tupper, Commanding Woolwich District in the chair.

I. The Notice convening the Meeting was taken as read.

II. The Abstract of the last Annual General Meeting was taken as read.

III. The Committee beg to submit the 50th Annual Report of the Royal Artillery Institution:—

1. There are now 1698 Members of the Institution, against 1651 last year. 101 Officers joined during the year, against 71 last year; whilst the deaths and withdrawals amount to 54.—*See Appendix C.*

The number of deaths was 15, against 12 last year. Among them are to be noted the names of the following Officers:—Field Marshal Sir R. J. Dacres, G.C.B.; General R. Sandham (Retired); Major-General G. A. Renny, V.C. (Retired); Major-General W. E. M. Reilly, C.B., Inspector General of Artillery; Major-General T. E. Hughes; Major-General J. Turner, C.B.

2. The accounts have been audited this year by Major C. B. Piers, Paymaster, R.A., and Major G. W. Barnes, A.P.D.

Appendix B shows that the financial condition of the Institution is highly satisfactory.

The cash which passed through the Secretary's hands amounted to £2589 7s. 4d., against £2523 1s. 11d. last year.

The General Credit, shown in the Capital Account, is £3074 3s. 11d., against £2915 15s. 11d. last year. The Liabilities are £306 6s. 9d., of which £95 18s. belongs to the Borgard Fund.

The amount in the Funds at par is £2300. No money has been withdrawn.

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3. Classes in Spanish have been formed at Gibraltar, and assisted in accordance with Rule XIX. Classes in Landscape Drawing have also been similarly assisted at Woolwich and at the Staff College. The amount expended in assisting officers in this manner has been £88. The Committee regret that during the past year they lost the services of the late Mr. Needham, who for so many years has been associated with the Drawing Class at Woolwich.

4. The Committee have continued the supply of Foreign Military Periodicals to Members willing to furnish from time to time, for publication with the "Proceedings," Reviews and Précis of their contents, as well as Translations in full of important articles.—*See Appendix I.*

5. The subject for the Prize Essay of the year was, "Mountain Artillery, its Organisation, Equipment and Tactics." Nine Essays were submitted for competition.

Colonel W. Stirling, C.B., Major N. Powlett, and Major A. E. Duthy, were good enough to act as Judges. The Committee acting upon their Report, decided to award a Gold Medal to the Essay with the Motto "*How beautiful upon the Mountains.*"

6. Colonel C. E. S. Scott, Major H. W. L. Hime, and Major E. Clayton, consented to act as Judges for the Rewards. In accordance with their Report, the Committee resolved to grant rewards to the writers of the following papers, whose names are given in alphabetical order:—

Grierson, Captain J. M.,	"Reviews of Prince Kraft's Letters"	£5
Hadcock, Qr.-Mr. A. G.,	"Shrapnel Fire"	£10
May, Captain E. S., ...	"Vertical Fire"	£5
Nash, Captain E., ...	Commended Essay, "Defence of a first-class Fortress"	£10
Tyler, Lt.-Col. T. B. ...	"Shield or Shelter"	£5

7. The following changes in the Committee took place during the year:—

Col. T. M. Hazlerigg... ...	vice	Maj.-Gen. W. H. Wardell.
Lt.-Col. W. F. M. Hutchinson	"	Lt.-Col. O. F. Le Mottée.
Major H. S. Murray-Graham	"	Major J. M. Alves.
" C. Morley	"	" S. C. Pratt.
" H. Pipon	"	" E. T. Browell.
" G. H. Marshall ...	"	" C. W. Long.
Capt. G. T. Kelaart	"	Lieut. F. L. Nathan.
" F. J. Fox...	"	Capt. A. H. Carter.
" E. M. Baker	"	Major J. R. J. Jocelyn.
Capt. R. M. Brady	"	Capt. F. J. Fox.

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The Committee on 31st March, 1887, was constituted as follows:—

PATRON AND PRESIDENT:

Field Marshal H. R. H. The DUKE OF CAMBRIDGE, K.G.

VICE-PRESIDENTS:

The Inspector-General of Artillery.
The Director of Artillery and Stores.
The Deputy-Adjutant-General, R.A.
The General Officer Commanding Woolwich District.

MEMBERS:

The Assistant-Adjutant-General, R.A.
The Director of Artillery Studies.
The Assistant-Adjutant-General, Woolwich.
The Secretary, Ordnance Committee.
General W. J. Smythe, F.R.S.
General Sir J. H. Lefroy, C.B., K.C.M.G., F.R.S.

Colonel E. Maitland	...	17	5	86	Major H. S. Murray-Graham		7	12	86
" T. M. Hazlerigg	...	5	11	86	" C. Russell	... ...	15	1	86
" W. W. Murdoch	...	16	3	85	Capt. E. M. Baker	... ...	8	7	86
Lt.-Col. W. F. M. Hutchinson		7	10	86	" W. A. G. Saunders		15	1	86
Major T. Wood	... ...	9	11	85	" G. T. Kelaart	... ...	7	6	86
" C. Morley	... ...	17	5	86	" E. S. May	... ...	15	4	85
" H. Pipon	... ...	10	5	86	" R. M. Brady	... ...	7	9	86
" G. H. Marshall	...	7	9	86	Lieut. F. V. Wing	... ...	17	8	85

Secretary.—Major H. H. Crookenden.

Assist. Secretary.—

Bankers:

Messrs. Cox & Co., and London & County Bank.

Solicitor:

E. W. Sampson, Esq., Woolwich.

TRUSTEES:

General Sir J. St. George, K.C.B.
" Sir C. Dickson, ~~V.C.~~ G.C.B.
D.-A.-G., R.A., for the time being.

IV. The Annual Report having been read to the Meeting, Lieut.-Colonel A. Burton-Brown asked whether the Laboratory having been handed over to the Department of Artillery Studies, Members of the Institution were thereby prevented from making use of it; he was informed that, on the contrary, Members of the Institution were welcomed there, provided no damage were done to the apparatus and instruments. The Annual Report was then adopted and accounts passed.

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V. The Secretary was requested to open the sealed envelope containing the name of the author of the Essay recommended for the Gold Medal. Capt. W. L. White was found to be the Gold Medallist for the year.

VI. It was proposed and carried that the subject for the Prize Essay for 1888 should be :—

"The relative importance of Mobility and Shell-fire in the Field Artillery."

This proposition having been submitted to H. R. H. the F. M. Commanding-in-Chief, was fully approved.

VII. The following propositions and amendments relating to the Rules and Regulations of the R.A. Institution were read to the Meeting.

1. Proposed and carried to strike out the words in 1st para., Rule XIX., "provided the Members in question do not receive pecuniary assistance from other sources."

2. Proposed and carried that an Additional Grant of £10 be allotted as honorarium to the Contributors of the most valuable Translations.

3. Proposed and carried that Instructors at the R.A. Institution be included in Para. 1, Rule II. amongst Professors eligible to become honorary members of the R.A. Institution.

4. Proposed and carried that any Member of the Committee not attending one Committee Meeting in six months shall cease to be a Member, and is ineligible for re-election for one year.

5. Proposed and carried that in order to make the Committee more representative, Commanding Officers and Heads of Departments be requested to name the Members as vacancies occur.

VII. Proposed and carried that a Review of the whole of the Prize Essays be written by some competent officer, provided the consent of the several writers can be obtained.

(Signed) G. Le M. TUPPER,
Major-General,
Chairman.

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UTION,

Receipts.

	£	s.	d.	£	s.	d.
.....				460	15	9
.....				51	18	11
.....				29	8	6
.....				259	16	8
.....				13	4	7
Entrance	103	0	0			
Annual	1359	19	0			
1880–1.....	0	10	0			
1881–2.....	0	10	0			
1882–3.....	1	16	0	1552	13	6
1883–4	8	12	0			
1884–5.....	20	19	0			
1885–6.....	46	5	0			
1887–8.....	9	7	6			
.....	1	15	0			
.....				111	17	11
....				42	6	8
graphs				0	10	10
.....				66	14	0
				£2589	7	4

Assets. **Cr.**

	£	s.	d.	£	s.	d.
.....				787	8	0
.....				2300	0	0
.....	41	6	7			
.....	20	11	4	84	17	11
tory	20	0	0			
.....	4	3	3			
.....	2	12	6			
.....	61	12	10			
.....	2	18	4			
.....	45	16	0	208	4	9
.....	59	7	7			
.....	31	0	3			
.....	0	14	0			
				£3380	10	8

H. H. CROOKENDEN,
Major,
Secretary, R. A. I.

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APPENDIX C.

Statement showing Increase and Decrease of Members of the R. A. Institution during the year ending 31st March, 1887.

Ranks.	1st April, 1886.	Increase.			Total increase.	Decrease.				Total decrease.	31st March, 1887.
		Promotions.	Retirement.	New Members.		Promotions.	Retirement.	Withdrawal.	Death.		
EFFECTIVE LIST.											
Generals and Regimental Field Officers	542	22	—	—	22	—	22	18	7	47	517
Captains	338	35	—	2	37	22	1	4	3	30	345
Lieutenants	508	—	—	97	97	35	—	4	2	41	564
Paymasters	1	—	—	—	—	—	—	—	—	—	1
Riding-Masters	1	—	—	—	—	—	—	—	—	—	1
Medical Officers	2	—	—	—	—	—	—	—	—	—	2
Veterinary Surgeons	2	—	—	—	—	—	—	—	—	—	2
Quarter-Masters	3	—	—	—	—	—	—	—	—	—	3
RETIRED LIST.											
Generals and Regimental Field Officers	132	—	22	—	22	—	—	8	3	11	143
Captains	65	—	1	—	1	—	—	2	—	2	64
Lieutenants	19	—	—	—	—	—	—	1	—	1	18
Paymaster...	1	—	—	—	—	—	—	—	—	—	1
Medical Officers	2	—	—	—	—	—	—	—	—	—	2
Chaplain	1	—	—	—	—	—	—	—	—	—	1
Honorary Members	34	—	—	2	2	—	—	2	—	2	34
Totals ...	1651	57	23	101	181	57	23	39	15	134	1698

APPENDIX D.

Presentations to the Library.

Madagascar. An Historical and Descriptive account of the Island, and its former Dependencies, by S. P. Oliver, F.S.A., F.R.G.S., *late* Captain R.A.	The Right Hon. the Secretary of State for War.
Treatise on the Manufacture of Guns, and Text-book of Service Ordnance. 3rd Edition, 1886.	

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The Armed Strength of Japan. Compiled in the Intelligence Branch of the War Office, by Captain J. M. Grierson, R.A.	The Right Hon the Secretary of State for War.
The Armed Strength of the Netherlands and their Colonies, with two maps.	
French Operations in Tong-King and Annam.	
Short History of Basutoland, by Captain L. Darwin, R.E.	
Précis of Information concerning Pondoland, including Port St. Johns.	
French Operations in Madagascar, 1882–86. Blue Book.....	
The Armed Strength of Russia (with two maps), prepared in the Intelligence Branch of the War Office, by Captain J. M. Grierson, R.A.	
Report on the circumstances attending an accident from the effects of fired Gunpowder, which occurred at Crarae Quarry, Loch Fyne, on the 25th September, 1886, by Col. A. Ford, *late* R.A., H.M. Inspector of Explosives.	The Right Hon. the Secretary of State for Home Department.
Report on the circumstances attending an Explosion which occurred at the Factory of Messrs. Kynoch & Co., (Limited), near Birmingham, on the 2nd Nov., 1886, by Major J. P. Cundill, R.A., H.M. Inspector of Explosives.....	
Report on the circumstances attending an accident at a display of fire-works at Batley, on the 24th of December, 1886, by Major J. P. Cundill, R.A., H.M. Inspector of Explosives.	
Tenth Annual Report of H.M. Inspector of Explosives for the year 1885.	
Accessions to the War Office Library. Nos. 3–4. 1st January, 1886–87.....	The Director of Artillery.
Handbook for the 6·3-inch R.M.L. Howitzer on bed and ground platform, or on siege travelling carriage (L.S.) 1886.	
Handbook for the 6·6-inch R.M.L. Howitzer (L.S.) 1886.....	
Lists of Service Ordnance, Fuzes, Carriages, &c. (10 copies).	
The Elswick Obturator. (2 copies).....	
Manual of Siege Artillery. 1886. (2 copies).	
Handbook for Scott's Telescopic Sight (L.S.). Description and instructions for using, &c.	
Handbook for the 20-pr. R.B.L. gun of 16 cwt., on garrison sliding carriage, and on travelling carriage. 1886.	
Handbook for the 8-inch R.M.L. Howitzer of 70 cwt. (Marks I. and II.) L.S..... ...	
Instructions for the defence of Submarine mines by fire from shore.	

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Manual of Field Range-Finding for officers and N.-C. officers of the Royal Artillery, and Text-book, School of Range-Finding, Aldershot. 1887.	The Director of Artillery.
Lithographs, coloured. R.C.D. Nos. 26A, 39A, 54B, 56B, 56C, 56D, 87A. R.G.F. Nos. 87, 89, 91–95, 101. R.L. Nos. 169–172.	
Handbook for Nordenfelt gun, 0·45-inch, 5 barrelled. Mark II. 2 copies.	
Report of the Ordnance Committee on the accident to 12-inch B.L. gun on board the *Collingwood*.	
Range Table for 10·4-inch R.M.L. gun	
" " " 9·2-inch B.L. gun. Mark I.	
" " " " " Mark III., IV. and V.	
" " " 3-pr. Hotchkiss quick-firing gun, based on practice 20th Oct., 1886.	
W.O. Photographs, Nos. 6614–6616, 6620–6622, 6652–6655, 6591–6613.	
Commission of the *late* Edmund Nugent, 1st Lieutenant Royal Irish Artillery, dated 7th August, 1793	D.-A.-General, R.A.
Journal of Experimental march of No. 7 (Heavy) Battery, 1st Brigade, Southern Division, R.A., from 22nd January to 9th February, 1886.	D.-A.-General, R.A. in India.
Report by the Director General of Military Education upon the 10th Senior Class at the Royal Artillery College, Woolwich, 1886	The Director General of Military Education.
Report on the Examination for admission to the Staff College, held in June, 1886	
Report of the final Examination at the Staff College, held in December, 1886.	
Observations of the International Polar Expedition, 1882–83. Fort Rae.	Meteorological Society.
The Royal Engineer's Journal (as published).	The Committee R.E. Institute.
Professional papers of the Corps of Royal Engineers. Volume X	
Report of the Astronomer Royal to the Board of Visitors of the Royal Observatory, Greenwich, June, 5, 1886.	The Astronomer Royal.
Results of the Magnetical and Meteorological Observations for the year, 1884.	
Annual Report of the Board of Regents of the Smithsonian Institution for the year 1884.	Smithsonian Institution.
Index to the Literature of Explosives, (Part I.) by Charles E. Munroe, Professor of Chemistry, U.S. Naval Academy	

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Notes on the Construction of Ordnance. Nos. 36, 37–39	Brig.-General S. V. Benét, U.S.A.
Annual Report of the Chief of Ordnance to the Secretary of War, for the fiscal year 1886...	
Patents and Patentees. Vol. XV. Victoria, 1885. With Indices for the year 1880.....	Government of Victoria.
Report of the Commissioner of Education for the year 1883–84.	Bureau of Education, U.S.
Annual Reports of the Department of Militia and Defence of the Dominion of Canada, 1885 and 1886.....	The Inspector General of Artillery, Kingston, Canada.
Annual Report of the Dominion Artillery Association, for the year 1885. 2 copies...	
Examination questions for officers and N.-C. officers of the Dominion Artillery Association. 1886.	
Prize List. Rules for practice, &c.	
Examination Papers. Royal Military Academy, Woolwich, February and July, 1886, and February, 1887.....	The Governor R.M. Academy, Woolwich.
Deutschlands Moose, Ein Taschenherbarium Zum Gebrauch auf botanischen Excursionen herausgegeben. Von Heinrich Christian Funck. One Volume with book of specimens. Baireuth 1820.	Colonel J. B. Richardson, R.A.
Large MS. Map of Burmah. Scale $\frac{1}{500,000}$.	
The Gunner, shewing the whole practice of Artillerie with all appurtenances thereunto belonging, by Robert Norton. One Volume. London, 1628.....	Colonel A. C. Gleig, *late* R.A.
A Treatise on Military Drawing and Surveying, by Captain W. Paterson. One Vol. 1862.	Captain J. B. Parkin, *late* R.A.
Mineral Resources of the United States, 1883–84, by Albert Williams, Junr.	Major G. Mackinlay, R.A.
Report of the Chapter of the Order of St. John of Jerusalem 1886	Colonel F. Duncan, C.B., M.P.
A collection of the R.A.I. Proceedings and other Professional Publications.....	Capt. Sir H. W. Gordon, K.C.B.
The War in Turkumania, Skobeleff's Campaign of 1880–81, by Maj.-General N. J. Grodekoff. Translated from the Russian, by Captain J. M. Grierson, R.A. Vols. 1–4.....	Captain J. M. Grierson, R.A.
Catalogue des Armes et Armures, Par E. Von Vinkeroy. One Vol. Brussels, 1885. ...	A. G. Greenhill, Esq., M.A.
Journal of the Royal United Service Institution. (As published).	The Council.
Journal of the United Service Institution of India. (As published).....	The Council.
List of Life Members and Annual Subscribers to the United Service Institution of India, corrected up to 24th August, 1886	

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Minutes of Proceedings of the Institution of Civil Engineers. (As published) ..... Brief Subject-Index. Vols. 59–86. Sessions, 1879–80 to 1885–86.....	The Council.
Proceedings of the Scientific Meetings of the Zoological Society of London. (As published).....	The Council.
Minutes of Proceedings of the Institution of Mechanical Engineers. (As published).....	The Council.
Proceedings of the United States Naval Institute. (As published).....	The Council.
Letters and addresses contributed at a General Meeting of the Military Service Institution, held at Governor's Island, New York Harbour, U.S.A., Feb. 25, 1886. In memory of Winfield Scott Hancock, *late* Major-General, U.S. Army..... Journal of the Military Service Institution of the United States. (As published)	The Council.
The Journal of the Iron and Steel Institute. (As published)	The Council.
Transactions of the Literary and Historical Society of Quebec. Sessions, 1883–1886	The Council.
On the Organisation and Duties of the Bearer Company of the Medical Corps in War, by Surgeon-Major G. J. H. Evatt, M.D.	The Author.
Modern Armour for National Defence, by W. H. Jaques, Lieut. U.S.N.....	The Author.
Notes on the Vegetation in the Suakim portion of the Soudan, by Major H. F. Smyth, R.A.	The Author.
Exterior Ballistics in the Plane of Fire, by J. M. Ingalls, Captain 1st Artillery, U.S. Army	The Author.
Proserpina. Studies of Wayside Flowers, by J. Ruskin, LL.D.	The Author.
Tablas Balisticas. 2nd edicion. Por Don Juan Duran y Loriga.....	The Author.
Emploi des Mitrailleuses et Canons a tir rapide dans Les Armèes de Terre et dans La Marine. Par Gustaf Roos. One Vol. St. Petersburgh, 1886	The Author.
A Tutor for the Auxiliary Artillery, by Captain C. E. Coffey, R.A.	The Author.
Russian Artillery Journal. (As published) ... " Military " "	Russian Government.
Revista Militär Española. (As published) ... Discusion Sobre Sistemas de Ascensos y Algemos Bases de Organizacion. Por un Oficial de Artilleria, Madrid 1886.....	Spanish Government.

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Commando Geral da Artilheria, Ordem. Nos. 5–8 of 1885 and 1–3 of 1886	The Director General of Artillery, Portugal.
Relatorio dos Trabalhos da Commissão de Aperfeiçoamento da Arma de Artilheria. no Anno de 1885	
Programma Para os Excercicios da Escola Practica de Artilheria no Polygono das vendas novas, no anna de 1886	
Regulamento Para o Serviço das Bocas de Fogo. A.E. 15^{c} p. (M.K.).....	
Regulamento de Manobras para a Instrucção da Artilheria Montada. Approvado por portaria de 9 de Dezembro de 1885	
Disposições Regulamentares de execução permanente tanto das ordens da direcção geral da Artilheria, como das repartições desde Janeiro de 1870 até Novembro de 1884, com um appendice das ordens, Nos. 1^{e} 2 do Commando Geral, publicadas no dito anno	
No. 2. Appendice Instrucções para Diversos Serviços	
Tegninger af Norsk Marine-Artillerie-Materiel, 5 heft. Plates 13, 13^{b}, 15	Swedish and Norwegian Government.
Revista Maritima Brazileira. (As published)	Brazilian Government.
Revista di Artiglieria e Genio. (As published)	Italian Government.
Giornale D'Artiglieria e Genio "	
Revista Marittima "	
Revue d'Artillerie. (As published)	French Government.

APPENDIX E.

Books, &c., Purchased.

Workshop Receipts. 2nd Series. By Robert Haldane. 1 Vol., 1883.
" " 3rd and 4th Series. By C. G. W. Lock. 2 Vols., 1885.
A Manual of Applied Mechanics. By W. J. M. Rankine. 1 Vol., 1885.
Encyclopœdia Britannica. Vol. XX.
Biologia Centrali-Americana. Zoology. Parts 46–57.
Schlachten-Atlas des Neunzchnten Jahrhunderts. Parts 2–7.
Official Year-Book of the Scientific and Learned Societies of Great Britain and Ireland.
Internationale Revue über die Gesammten Armeen und Flotten (Monthly).
Birds of New Guinea. By J. Gould, F.R.S., &c. Parts 21–23.
Supplement to the Trochilidœ or Humming Birds. By J. Gould, F.R.S. Part 5.
Præterita. Chapters 1–12, Vol. 1., Chapters 1–10, Vol. 2. By J. Ruskin, LL.D.
Histoire des Sciences Mathematiques et Physiques. Par M. Marie.
The Siderial Messenger of Galileo Galilei. 1 Vol. 1886.
Tactical Studies from the Franco-German War. 1 Vol. London, 1886.

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Canons Francais et Canons Allemands. 1 Vol. 1886.

The Story of the Heavens. By Sir R. S. Ball, LL.D.

Militarische Briefe. I. Ueber Kavallerie. III. Ueber Artillerie.

Foreign Armies, their formation, Organisation, and Strength.

The Nautical Almanack, and Astronomical Ephemeris, for the Years 1887–89.

The Naval Annual, 1886. By Lord Brassey, K.C.B. 1 Vol. Portsmouth, 1886.

Handbook of Practical Telegraphy. By R. S. Culley. 8th Edition. London, 1885.

View of the Royal Artillery Barracks, Woolwich, 1816. From the Original, by Major Cockburn, R.A.

Portrait of the Hon. Lieut.-General Sherard, Colonel of His Majesty's 69th Regiment, when Col.-Comdt. of the 2nd Battalion 1st Regiment of Foot Guards, accompanied by Captain Tiffen, R.A., relieving with his Battalion a picquet of Hanoverians who were posted in a Redoubt to defend the passage of the Brugher Mühl (near) Amaneburgh in Hesse, on the 21st September, 1762.

Exercir-Reglement für die Feld Artillerie. 1877.

Die Weltstellung Englands. Berlin. 1886.

Strategie et Grand Tactique. Par Général Pierron. 1 Vol. Paris. 1887.

The Steam Engine. By G. C. V. Holmes. 1 Vol. London. 1887.

Krupp et de Bange. Par E. Monthaye. 1 Vol. Brussels. 1887.

Reglement sur les Manœuvres des Batteries Attelees. 1886.

The Ibis. A Quarterly Journal of Ornithology.

APPENDIX F.

Presentations to the Museum.

Hammock made by Indians, from the Mazarin River, British Guiana.	H. Whitely, Esq., Junr., C.M.Z.S.
5 Pieces of Pottery made by Indians of the interior of British Guiana	
20 Birds from the Carimang River, British Guiana	
3 Pieces of Ancient Pottery from the Valley of the Rio Cosnipata	
2 Feather Head Ornaments, worn by the Chiefs of the Choncho Tribes of the South American Indians	
1 Feather Girdle, worn by the Females of the Choncho Tribe of South American Indians	
1 Zulu (fighting) Shield	Lieut. H. L. A. Jenkinson, R.H.A.
2 " Assegais.	
1 " Carved Wood Pillow	
1 " Snuff Box	
5 Specimens of Tulip Grass from Natal	

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Table used by the Officers' Mess, N/5, R.A., during the Campaigns in South Africa, in the Years 1878–79, 1880–81, in folding case, with plate inserted in the centre bearing names of Officers who served in the Battery during the periods mentioned.	Col. A. Harness, CB., R.A.
Union Jack, made by the Ladies of Prætoria, Transvaal, on Annexation	Lt.-Col. H. Vaughan, *late* R.A.
Silver Coin (Tyre) Circă, B.C. 115.....	Messrs. Davis & Co.

APPENDIX G.

List of Papers published in the "Proceedings" during the Year.

Experiments against Wrought-iron Plates with the 9·2-inch B.L. Armstrong gun. By Captain A. P. Penton, R.A.

Description of a Burmese Jingal. By Lieut. C. P. Fendall, R.A.

The Arming of Drivers in the R.H.A. and Field Batteries. By Captain W. N. Lloyd, R.A.

Diary of the Operations in Spain under Sir John Moore. By Captain Adam Wall, R.A., commanding 4th Company, 7th Battalion, now 'A' Battery, 1st Brigade, R.A.

Field Artillery Tactics. A Review. By Captain J. M. Grierson, R.A.

Examination of the Metal and Rust of certain Guns after long immersion in Sea Water. Communicated by the Secretary.

Notes on the Method of Compiling a Range Table. By Commander H. J. May, R.N. Communicated by the Secretary.

The Trajectory for the Cubic Law of Resistance. By A. G. Greenhill, M.A., Professor of Mathematics to the Advanced Class of Artillery Officers, Woolwich.

March of the Right Division, Hazara Mountain Battery. By Lieut. A. H. C. Birch, R.A., 1st Subaltern, No. 4 Hazara Mountain Battery.

Short History and Description of Armour and its attack by Artillery. By Captain Orde Browne (late R.A.) Continued from No. 8, Vol., XIV., p. 302.

Vertical Fire in the Field, and how the question is regarded in Russia. By Captain E. S. May, R.A.

Shield or Shelter. By Major T. B. Tyler, R.H.A.

Extracts from the "History of the Royal Artillery." Lieut.-Colonel JONAS WATSON. Communicated by the Secretary.

A Simple Method of Range Finding from Coast Batteries when in Signalling Communication with each other. By Colonel Stapleton Penny, R.A.

Abstract of the Proceedings of the Forty-ninth Annual General Meeting of the Royal Artillery Institution.

The Volunteer Field Battery, Bechuanaland Field Force. By Major E. A. Ollivant, R.A.

Reports of Experiments with Nordenfeldt's Submarine Boat. By Lieut. J. H. Thomson, R.H.A. Communicated by the D.-A. General, R.A.

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A few more Remarks on Fortification. By Lieut. C. E. Callwell, R.A.

The General Arrangement and Practical Working of the Artillery Defence of a First-class Fortress, protecting a Harbour and Dockyard. The Gold Medal Prize Essay. By Major A. W. White, R.A.

Proposed System for Checking the Recoil of Heavy Guns. By Lieutenant F. R. Maunsell, R.A.

Extracts from the Diary of Captain Pococke, 71st Highland Regiment, while a Prisoner in Buenos Ayres, 1806–1807. Contributed by Lieut.-Colonel W. H. M. Duthie, *late* R.A.

Use of Portable Rails. Moving two 38-ton guns on Portable Rails to Colaba Point Battery. By Colonel Stapleton Penny, R.A.

Arming the Personnel of Horse and Field Artillery. By Captain E. A. Lambart, R.A.

The General Arrangement and Practical Working of the Artillery Defence of a First-class Coast Fortress protecting a Harbour and Dockyard. The Silver Medal Prize Essay. By Major R. W. Rainsford-Hannay, R.A.

The General Arrangement and Practical Working of the Artillery Defence of a First-class Coast Fortress protecting a Harbour and Dockyard. The Commended Essay. By Captain E. Nash, R.A.

On the Rejection of Abnormal Rounds in Trials for Accuracy of Shooting. By Major H. W. L. Hime, R.A.

Some American Books. A Review. By Major G. Mackinlay, R.A.

Précis of Lydd Experiments, 1882–3. (In continuation of the account of the Dungeness and Lydd Experiments, published in No. 5, Vol. XIII.) By Colonel F. G. Baylay, R.A.

Abstract of the Proceedings of a Special General Meeting.

War Services of certain Officers of the Regiment which are not given in Kane's List, and of certain others which are only imperfectly given. Communicated by General Sir J. H. Lefroy, C.B., K.C.M.G., F.R.S., LL.D., R.A.

No. 8.—Lieut.-General Robert Lawson, Colonel Commandant 10th Battalion, Royal Artillery.

Landing the 110-ton B.L. Gun at the Royal Arsenal, Woolwich. Communicated by Colonel J. T. Barrington, Ordnance Store Department, Royal Arsenal.

Artillery. A Review. By Captain J. M. Grierson, R.A.

The Effect of Projectiles on Armour Plates. A Review. By Capt. E. May, R.A.

Notes on the Stable Management of a Field Battery in India. By Lieut. G. E. Benson, R.A.

Experimental March of No. 7 Battery, Southern Division, Royal Artillery. By Major P. H. Hammond, R.A.

Shield *versus* Shelter. A suggestion. By Lieut. P. Foster, R.A.

Short History and Description of Armour, and its Attack by Artillery. (Continued from No. 11, Vol. XIV., p. 438). By Capt. C. Orde Browne, *late* R.A.

Indirect Fire, Field Artillery. By Major J. Leach, R.A.

Précis of Lydd Experiments, August and September, 1884. In continuation of the account published in No. 14, Vol. XIV. By Colonel F. G. Baylay, R.A.

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Cavalry. A Review. By Captain J. M. Grierson, R.A.

Old and Rare Books in the R.A. Library. Re-printed from Notes issued with No. 9, Vol. XII., and Nos. 6 and 7, Vol. XIII. Communicated by the Secretary.

Discussion on the R.A.I. Prize Essays published in Nos. 12 and 13, Vol. XIV. Major-General H. A. Smyth (Commanding Woolwich District) in the chair.

Copy of Report of visit to Mandalay and the Irrawaddy Forts, Upper Burma. By Colonel W. Carey, C.B., Colonel on the Staff, Commanding R.A., British Burma.

Firing at Balloons of Observation. By Captain W. H. H. Waters, R.A.

Reduction of Bashforth's Experiments by Interpolation. By Professor A. G. Greenhill, M.A., and Lieut. F. L. Nathan, R.A.

An Account of some old wrought-iron built-up Guns taken over in Fort Jhansi, in March, 1886. By Major P. H. Hammond, R.A.

Memorandum on a Portable Heliograph. Designed by Captain R. H. Mahon, R.A.

Account of the Burmese War of 1885–86. By Colonel W. Carey, R.A., Commanding R.A., British Burma.

Grant's Apparatus for the Automatic Sighting of Heavy Guns on High Sites. Communicated by Colonel J. B. Richardson, R.A.

Proposed Hydraulic Method of Mounting Ordnance. By Lieutenant F. R. Maunsell, R.A.

The Protection of Heavy Guns for Coast Defence. By Captain G. S. Clarke, R.E.

The Nile Expedition of 1885. (A Lecture delivered at the R.A. Institution, Woolwich.) By Colonel F. Duncan, C.B., M.P., R.A.

The Attack Formation of Infantry. By Lieut.-Colonel G. B. Macdonell, R.A.

Field Shrapnel Fire. By Mr. A. G. Hadcock, R.A., Inspector of Ordnance Machinery.

A Narrative of Six Weeks' Siege Operations. By Lieut. G. R. Lamb, R.A.

The Garrison Gunner. By Captain E. Nash, R.A.

Replacing disabled Horses in a Team. By Major G. R. Gambier, R.H.A.

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APPENDIX H.

Precis and Translations published during the year.

FRANCE...
- "Revue d'Artillerie." February, 1886. By Lieut. G. E. Weigall, R.A.
  - Note on the Fire of Artillery over the heads of Infantry.
- "Revue Militaire de L'Etranger." December, 1885. By Major J. H. G. Browne, R.A.
  - The present tendencies of the Russia Cavalry—continued.
- "Memorial de L'Artillerie de la Marine." Vol. XIII., 1885. By permission of the Council of Civil Engineers.
  - The Strength of Rifled Guns.
  - Cause of Erosion in the Bore of Guns.
- "Revue Militaire de L'Etranger." March, 1886. By Major J. H. G. Browne, R.A.
  - The Tactical Employment of Field Artillery in the Russian Army.

GERMANY
- "Militär Wochenblatt." Nos. 19 and 32, 1886. By Captain E. May, R.A.
  - Considerations on the Origin of Recoil.
- "An Account of the Servo-Bulgarian War of 1885." From the German. By Lieut. H. S. White, R.A.
- "Letters on Artillery." By Prince Kraft zu Hohenlohe Ingelfingen. Nos. 1 to 3. Translated by Major N. L. Walford, R.A.
- "Militär Wochenblatt." No. 61. 1886. By Captain E. S. May, R.A.
  - Considerations on the Employment of Horse Artillery in conjunction with Cavalry.

AUSTRIA
- "Mittheilungen, &c." By Lieut. St. J. L. H. Du Plat-Taylor, R.A.
  - Electro-Ballistic Chronographs at the Vienna Exhibition, 1883.

Articles on various subjects noted in English and Foreign Periodicals during the months of February to September 1886. By Major A. W. Anstruther, R.A.

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APPENDIX I.

List of Magazines and Journals, R.A. Institution;

With the Names of Officers who have undertaken to supply Précis and Reviews of their contents from time to time.

COUNTRY.	NAME OF JOURNAL, &c.	TRANSLATOR.
France ...	Spectateur Militaire.....	—
	Journal des Sciences Militaires	Captain W. P. Thring.
	Revue d'Artillerie	Lieut. G. E. Weigall.
	Revue Militaire de l'Etranger	Lt.-Col. J. H. G. Browne.
Spain ...	Revista Militar Española.....	Major J. C. Dalton.
	Memorial de Artilleria.....	—
Germany	Neue Militärische Blätter	Captain E. S. May.
	Archiv für die Artillerie-und-Ingenieur-Officiere	Lieut. Du Plat-Taylor.
	Militärische Klassiker	—
	Militär-Wochenblatt	Captain E. S. May.
Austria...	Organ der Militär-Wissenschaftlichen Vereine	—
	Militärische Zeitschrift	—
	Mittheilungen, &c., des Artillerie- und Genie-Wesens	—
	Mittheilungen des K. K. Kreigs-Archivs	—
Italy.....	Italia Militare	Lieut. G. E. Weigall.
	Rivista di Artiglieria e Genio	—
	Giornali	—
Russia ...	Journal of Artillery.....	—
	Vojenni Sbornik	—
	Russky Invalide	Capt. W. H. Waters.
Servia	Journal of Military Science, &c.....	—
Sweden	Artilleri-Tidskrift	—

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MOUNTAIN ARTILLERY, ITS ORGANISATION, EQUIPMENT AND TACTICS.

"How Beautiful upon the Mountains."

GOLD MEDAL PRIZE ESSAY, 1887.

BY

CAPTAIN W. L. WHITE, R.A.

Organizatio Establishments

The establishment of a mountain battery as at present laid down in England[1] has been calculated on the lavish scale of Indian requirements, necessarily large when we regard the stupendous ranges of hills and the great distance at which the batteries generally find themselves from their base of supplies. It must be borne in mind, as a cardinal fact, that mountain batteries are often liable, from tactical considerations, to be split up into divisions, and as in a mountainous country communication with other parts of a force is difficult and tedious, it is absolutely necessary that each division should be complete in itself and capable of acting independently.

Indian

The completeness of a mountain battery will be seen by a glance at table D, page 404, which shows an establishment almost identical with the official Indian organisation. These numbers have been arrived at by Indian authorities after so much thought and experience that they may be accepted on the whole as eminently practical for the work the batteries have to perform.

But there are other countries where mountain batteries may be called upon to fight and where the requirements of transport are not so great. The task then I have set myself in the following pages is to try and arrive at an establishment which shall be suitable for such countries, calculated on the lowest and most economical scale compatible with efficiency, showing the increase necessary for different kinds of country and climate until we arrive at the Indian establishment, which may be taken as a maximum, calculated for service in one of the most difficult countries in the world.

The lowest possible war establishment may be taken as that necessary for a campaign in an European country where a certain number of roads are available. In order to get data to guide us it is necessary to look at the establishments of some foreign armies, notably the Austrian, Spanish, and Italian, the latter of whom have arrived at no small degree of excellence in their Alpine batteries.

[1] Handbook 2·5-in. jointed gun Imperial Service, 1887.

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Comparison of a Battery on Scale **D** with a Russian Battery of 2·5-inch guns calculated for Service under somewhat similar conditions of Country and Warfare.

ENGLAND.			RUSSIA.		
Number of guns per Battery		6	Number of Guns per Battery ...		8
Ordnance Mules.			*Ordnance Horses.*		
Gun chase { 1st Line	6		Gun	8	
Gun chase { Relief	6		Carriage { breast	8	
Gun breech { 1st Line	6		Carriage { trail	8	
Gun breech { Relief	6		Wheels	8	
Carriages { 1st Line	6		Ammunition	64	
Carriages { Relief	6		Spare carriage	3	
Axletrees { 1st Line	6		For Sergts. of Ammunition Line ...	2	
Axletrees { Relief	6		Spare Materials...	2	
Wheels { 1st Line	6		Artificers Tools	2	
Wheels { Relief	6		Farriers Tools and Forge...	4	
Ammun^{n}. { 1st Line	6		Spare shoes and nails	3	
Ammun^{n}. { Relief	6		Veterinary Stores	1	
Ammunition Line	30		Line gear	3	
Pioneers	3		Spare wheels and shafts	2	
Artificers Tools	3		Spare for { guns, &c.	13	
Spare Carriage	3		Spare for { stores	2	133
" " Relief	3				
Forge	1				
Spare (bare-backed)	18	133			
Baggage Mules.			*Baggage Animals.*		
Officers	4		Officers	7	
Kits, N.-C.-O.'s and Men...	32		Kits, Men	4	
Cooking pots and rations...	6		3 days' rations	10	
Water Mules	6		2 days' forage	18	
Stores, and half-wrought	6		Camp kettles	4	
Office	1		Hospital Stores	3	
Veterinary Stores	1		Office and Treasure	1	
Charcoal	1		Shoes and Nails...	1	
Spare (saddled)	6	63	Tents	10	
			Line Gear	1	
			Spare	6	65
Total		196	Total		198

The tables on page 420 show the mountain battery establishments of several European powers.[1]

In an Austrian battery the war establishment is as follows:—[2]

111 Officers and men; 4 guns.

Ordnance mules.	Gun	4	Field forge	2
	Carriage with wheels	4	Provisions	2
	Spare carriage ...	1	Officer's baggage ...	1
	Ammunition	28	Spare (saddled) ...	2
			Total ordnance mules	44
Baggage mules	Men's kits			5
	Reserve Artillery material			3
	2 days' provision and forage			11
			Total baggage mules	19
			Total war establishment mules...	63

[1] Compiled from "Die Gebirgs Artillerie in den Europäishen Armeen;" Beckerhinn, 1883, and corrected from the "Armed Strengths" and General Orders of various nations.

[2] "Armed strength of Austria."—Artillerie Unterricht für Unter-Offiziere und Vormeister der 7^{cm} Gebirgs Batterien.

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Austrian mixed

This establishment of 63 mules is termed the normal, but if the theatre of war is in a country where roads are available or wheeled traffic possible, the 19 baggage mules are replaced by two pair-horsed country carts, and only 103 officers and men are required, thus effecting a saving of 15 animals and 8 men per battery. This is known as the mixed establishment. Russia also acknowledges a mixed establishment.[1]

Russian mixed

Italian

In the Italian Alpine batteries,[2] each consisting of four guns, the establishment is much the same as the Austrian. The war strength of a battery, omitting the animals carrying the two days' provision and forage, being 55.

English

If the foregoing numbers be compared with the English establishment, as at present laid down, of 294 officers and men and 196 mules for a six-gun battery, it will be seen that considerable reductions may be made, it is submitted, without loss of efficiency in an European campaign.

The following estimates of establishment are based on the requirements of the 2·5-in. gun, which the table on page 421 [3] will show to be the most powerful gun in possession of any Mountain Artillery. The establishments as proposed are shown in table A, page 417, and Plate II.

Relief Line

The great saving in the number of animals in foreign mountain batteries is effected by the abolition of the relief line, which exists in none of them. The presence of roads and open country in their possible theatres of war allows the first line to be relieved by the use of shafts.

Proposed amalgamation with ammunition line

Considering the countries English gunners have not infrequently to fight in it would be inadvisable to do away entirely with the relief line, but the number of mules per battery may be greatly reduced by its amalgamation with the ammunition line. That is, the mules of the second line shall be saddled as a relief line and the load of each consist of two sets of line gear (for self and corresponding mule of 1st line) and two boxes each containing four rounds (three shrapnel and one common). The relief wheel mule to carry three rounds of star shell in addition. Average weight of these loads being 132 lbs.

Table of Ammunition proposed to be carried.

Ammunition carried

Rounds per Gun.	1st Line.	2nd Line.	Total.	Per Battery.
Peace Establishment	20	51	71	426
Additional for War	16	8	24	144
	36	59	95	570
Add rounds carried by spare carriage relief				31
Grand Total				601

[1] Armed strength of Russia, 1886.

[2] Armed strength of Italy. Rivista d'Artiglieria e Genio.

[3] Compiled from "Die Gebirgs Artillerie." Beckerhinn and various other sources, such as handbooks, &c.

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mmunition arried

Rounds per Gun.	1st Line.			2nd Line.				Total.	Per Battery.
	common.	shrapnel.	case.	common.	shrapnel.	case.	star.		
Peace Establishment	4	10	6	12	36	—	3	71	426
Additional for War	4	10	2	2	6	—	—	24	144
	8	20	8	14	42	—	3	95	570

	Common.	Shrapnel.	Case.	Star.	Total.
Totals 1st and 2nd Line	132	372	48	18	570
Carried by spare carriage relief	6	18	4	3	31
Grand Totals	138	390	52	21	601

aggage line

For the baggage line, in time of peace, I am inclined to adopt the Austrian and Russian system of mixed establishment. This has been done to a certain extent in India. At Umballa, light two-wheeled carts are issued, each as the equivalent of six baggage mules.

This mixed establishment is economical in an European country in peace time and if the battery be provided with pack saddles for a baggage line each division may be practised in turn in the adjustment of its baggage for pack transport by borrowing, for the time, mules from the other divisions.

The baggage question is one of great importance as a large number of animals is required. Other nations solve the difficulty by making the men carry their own kits or a large portion of them. In a temperate or cold climate the men might be called upon to carry their own great coats, and the following portion of their kits, viz., one flannel shirt, one pair socks, one mess tin, one hold-all, one towel, one piece soap, one small box of grease, and an iron ration for one or two days. The remaining pair of socks, spare boots, &c., to be carried with his blanket, sleeved waistcoast and waterproof sheet on baggage mules or in carts.

its

The abovementioned load (about 10 lbs. including great coat) would not seriously inconvenience an athletic man in mountain marching, and would permit a reduction in the number of baggage animals.

Moreover by placing a slight load on the men the present tendency of the men to overwalk the laden mules on level ground or down hill slopes, would be reduced.

oposed xed estab- nt

The baggage line will consist of one pair horsed wagon or cart per division which would easily carry all the extra kits, cooking utensils, officer's baggage and stores (also tents when necessary) of the battery in England or on most campaigns in Europe or Western Asia.

If the battery be required for a war in a country where roads are available the addition of one pair of horses per wagon or cart would be sufficient to bring the baggage line up to war strength.

arate ef and munition

If wheeled traffic be impossible in the theatre of war the wagons will have to be withdrawn and pack animals substituted, *vide* tables B and C, page 417. If the country be a particularly difficult one, the

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introduction of a separate relief and ammunition line must be considered as shown in table D, page 404.

I wish to lay great stress upon the necessity for reducing to a minimum the number of animals and men requisite in a battery. It firstly affects the all important question of supply, a point of no small magnitude, as mountainous districts rarely afford large local means of subsistence; secondly, in the present days of large armaments economy must be one of the great points aimed at so long as it does not impair efficiency.

Necessity of reducing to a minimum the number of animals and men

In the consideration of the *personnel* of a battery, other points besides those of numbers arise. If such a battery or batteries as I suggest were to exist in this country, for employment in a campaign in Europe or Western Asia, in time of peace they would have to act as depôts for batteries in India and also periodically to relieve those batteries; unless indeed a special depôt for mountain batteries were provided such as that suggested on page 418. The difficulty is that for purposes of relief or drafts the European driver, as such, would not be required, for in India all drivers are natives. The matter may be arranged in this way. The drivers should be of the same physique as the gunners and be available for India in the latter capacity.

Depôt battery

Gunners and drivers

This scheme will be more readily understood by reference to table and diagram A, from which it will be seen that the number of gunners required for the peace establishment of a battery is 90, of whom 33 will be temporarily employed as drivers, and 60 drivers of whom six are spare.

(The mounted drivers of the wagons would of course be small men and might be interchangeable with the Field Artillery for Indian service).

On bringing the battery up to war strength the 33 gunners would rejoin their detachments, thus leaving a large margin of spare men, and their places would be taken by hired muleteers, of whom 45, 56, 67, or 100, would be required according to the scale A, B, C, or D, on which the battery was to be completed.

As a peace establishment for the purpose of supplying drafts for India some 60 to 70 trained gunners could be supplied annually without seriously impairing the efficiency of the battery, bringing forward the 60 drivers to complete their education as gunners and supplying their places with recruits.

The foregoing calculations show a battery on a peace footing capable of being rapidly expanded to war strength or acting as a depôt for batteries abroad. For a depôt pure and simple a still smaller establishment would be sufficient. The diagram, page 418, will show what is necessary in the way of animals for instructional purposes for which one complete division with baggage mules could be turned out. In time of war this depôt could be turned if required into two Artillery and one Infantry ammunition columns as shown on page 419.

Artillery and infantry ammunition columns

The question of the organisation of mountain batteries in brigades is a purely administrative one and possibly beyond the scope of this essay. The country which can supply us with the best example that applies to our own situation is Spain, which has several mountain

Mountain Artillery brigades

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batteries in the West Indies and the Phillipine Islands.[1] The brigades are all composed of six batteries and a depôt. No. 6 battery, though provided with two guns in time of peace for instructional purposes, is expanded in time of war into two Artillery and one Infantry ammunition columns.

Equipment

Dress

Exigencies of space have compelled me to to cut out some remarks on dress, arms, and accoutrements. The dress should be much the same as that at present worn in India; the arms, a sword and stout double-barrelled pistol.

So much care and thought has been expended on the very smallest article of mountain equipment at present in the service that I shall venture to adopt the equipment as it stands, and, supposing the reader to be familiar with the details of it, proceed to criticise and suggest the alterations necessary to bring it to the pattern of my ideal battery.

Different features of country require different guns

Mountain warfare may be carried on in two kinds of country.[2] Firstly, in the mountains proper, or secondly, in the broader valleys or undulating ground at the outskirts of the mountainous tract, and it is here that the decisive actions of a mountain campaign usually take place, *e.g.*, the campaign of 1799 in Switzerland and that of 1878 in Bosnia.

Each class of country exacts a different method of fighting and requires a different method of Artillery fire.

In the mountains proper, owing to accidents of ground it often happens that the enemy's position comes suddenly into sight at a comparatively short range, or that by using dry water-courses (Taufers, 1799) and other natural and indestructible cover, the enemy may approach close to our position unseen. Again, the small columns, with which mountain warfare is usually carried on, are often unable to detach a sufficient escort for the guns; the latter therefore keep close to the Infantry and move up to short ranges. Briefly. It is not that long ranges do not exist but that accidents of ground allow the enemy to move to shorter and more decisive ranges at once.

Howitzers

Considering the above points we see that what is principally required for the first case is a gun or howitzer of large shell capacity, and weight being limited, of consequent low ballistic powers, from which a heavy curved or high-angle fire at short ranges can be kept up. An historical retrospect of the Mountain Artilleries of Europe for the last two centuries shows that this object has been kept in view by contemporary Artillerists, their efforts culminating in the French 12-pr. bronze howitzer of 1829, the Austrian bronze 12-pr. howitzer of 1844, the English 4⅘-in. 12-pr. howitzer and the present French 12-pr. steel B.L. low velocity gun.

Field guns sometimes used

In the second case, however, longer ranges are obtained and the troops move in larger masses. Here then the powerful gun with high initial velocity will be appreciated, and such we find in the 2·5-in. jointed gun of 400 lbs. European nations rely, to a large extent, on the presence of field guns for these actions, hence the striving after

[1] Mittheilungen über Gegenstände des Artillerie und Genie Wesens, May, 1883.

[2] Der Gebirgskreig. General Von Kuhn.

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large shell capacity for purely mountain work.[1] In 1881 the Austrians employed 9cm. field guns on narrow track carriages for these actions,[2] but I believe they did not secure any large measure of success on account of the difficulties of transport through the mountainous tracts.

Proposed pieces for India

At the request of the Indian Government, for the first case, a jointed 20-pr. howitzer in three pieces and for the second case a powerful gun also in three pieces and carrying a ten pound shell have been submitted and are under trial. They promise well although in both cases the correct limit of number of pieces into which the gun can be divided has, in my opinion, been exceeded. This number should not exceed two to minimise the chance of disablement owing to the loss of a portion.

Question of weight

The whole question of equipment is dominated by the question of weight. It is recognised by English Artillerists that an ordnance mule is capable of carrying two cwt.[3] in addition to the weight of his saddle &c., and this rule is adhered to by continental powers as will be seen by the table below,[4] with the exception of Spain where very

Weights of Loads including Saddlery.

Weights carried by Mountain Artillery of different Powers

Mule.	England.			Austria.	France.	Italy.	Spain.	Greece.
	7-pr. lbs.	2·5-inch. lbs.	15-pr. lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Gun { chase	282	305	305	290	314	313	392	201
Gun { breech		321	340				With wheels.	
Axletree	296	259	276	308	275	324	335	275
1st carriage		301	301					
2nd "					318			
Wheels	244	345	257	—		337	335	255
Ammunition	329	315	296	289	315	363	432	—
Average Load... ...	288	308	296	295	305	332	373	—

large mules are used and this weight is exceeded. A gun of two cwt. is not powerful enough to meet all cases, a jointed gun is therefore necessary.

Determination of calibre

The calibre of the piece is limited by the consideration that of heavy projectiles but few can be carried on one mule, and in order to retain the authorised proportion of projectiles per gun, an abnormally large number of ammunition animals will be required if the calibre be very large.

Jointed gun, 2·5-inch

I accept then the gun in two pieces as the type of weapon for my battery, and take the 2·5-in. gun as a specimen of that type. I submit a plan by which a certain amount of high-angle fire may be got at short ranges from this gun. If the scheme be not feasible, then we must have howitzer batteries also, and I would select a weapon in two pieces of the same weight as the gun, and taking a shell of 12 to 14 lbs. for heavy batteries and retain the 7-pr. of 200 lbs. for light batteries and

[1] Der Gebirgskreig; Genl. Von Kuhn. Genl. Rossi, Revista d'Artiglieria, Dec., 1885.

[2] Organ des Militär-Wissenschaftlichen Vereine, Part I., Vol. XXV.

[3] Pack Transport Committee, 1884. Manual for Mountain Artillery, India, 1882.

[4] Compiled from Die Gebirgs Artillerie. Beckerhinn and other sources.

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for wars against an indifferently armed enemy. The organisation of such a howitzer battery would be similar to that shown on pages 404 and 417, with an increased number of ammunition mules on account of the extra weight of the projectiles.

Little more could be desired in accuracy from the 2·5-in. gun, and when men have become accustomed to the screwing up, it is easy to manipulate. Recent changes in the gas ring and the provision of a leathern buffer for the sight ring have removed grounds of objection. The introduction of a reciprocating sight minimises the errors in practice arising from uneven platform.

Grounds of objection

The principal ground of objection is that the muzzle velocity is so high and the trajectory so flat that it is a matter of great difficulty to search out a ravine or sweep the reverse slope of a hill at comparatively short ranges: another ground of objection has recently come to light. In the present campaign in Burmah the fighting is often at exceptionally short ranges (sometimes not more than 200 yards in a dense jungle). At these ranges the shell from the 2·5-in. gun punch a neat hole in the bamboo or teak stockades of the enemy and go singing away to the rear without exploding, whereas those of the 7-pr. going at a lower velocity lob up against the stockade, burst, and bring down a whole rood of paling. In the footnote [1] I suggest a way in which these difficulties might be overcome, but as it is perhaps chimerical I have not allowed for it in the calculation of establishment and therefore exclude it from the body of this essay.

Proposed remedy

Carriage: Division of load

The division of the carriage load has been the subject of much experiment, Plates III. and IV., show the methods adopted by France and Russia. I consider our method of separating the axletree from the carriage is superior to either as presenting a stronger trail to resist a violent recoil.

Attachment of axletree faulty

I think that the system of attachment of the axletree requires modification. There is a tendency, when in a hurry, not to screw up the axle clips sufficiently, which throws an undue strain on the carriage.[2]

Violent recoil

The recoil of this gun is great and might prove a serious matter in a cramped position as it is too violent to be held with drag ropes like the 7-pr.

Suggested remedy

The following experiment might be tried of the insertion of a stout spring or elastic link [3] into each end of the check rope. This I take it might tend to reduce the recoil by giving slightly on the shock of discharge and rotating the wheels in a contrary direction as the spring recovered.

Shaft draught

I propose to submit my views on shaft draught in another paper,

[1] The chase portion of the gun to have a pair of light trunnions about half way between the muzzle and the junction nut. A second breech portion, consisting merely of a steel block containing a small chamber with vent about an inch from bottom to be carried, which could be screwed up in the usual manner to the chase, and thus a gun of about 240 pounds weight for firing shell with reduced charges from the carriage would be provided.

[2] This might be remedied by making the clip plates a fixture; passing the axletree through brackets of the carriage and securing it by two small wedges driven outwards along its upper surface by a rocking lever or eccentric at the breast of the carriage. The additional weight being compensated for by the abolition of the heavy clip bolts and nuts.

[3] R.A.I. Proceedings, October, 1884.

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and summarise by saying that some method of traction should be, in my opinion, available if required. The method of draught at present in vogue with the 2·5-in. gun is not practical for more than the shortest distances. Present system

The light nature of mountain guns in use by foreign armies makes the attachment of shafts to their carriages a comparatively easy question, and they are used by Austria, France, Italy, Russia, Spain, Greece, Servia, and Switzerland. The heavier nature of the 2·5-in. gun and carriage require some modification of the shaft system, and I think the plan improvised by H/4, R.A., at the Cape, with these guns is based on a sound principle. A light pole was placed between the brackets of the carriage butting the end against the inside of the breast. The end of the trail was then made fast to the pole. At the end of the pole a lashed cross-piece rested on the pads and in front of the cradles of two ordnance mules, the gun being thus drawn curricle fashion. Foreign armies using draught. Plan of H/4 R.A. at the Cape.

What I propose (*vide* Plate V.) is a short bamboo pole fitting into the handspike socket, secured with a pin and fitted with a cross bar, strap and swivel at the other end, each extremity of the bar to work on a hook and roller in front of an ordnance cradle. The hooks already there to be modified as shown in the plate. The advantage claimed is that the pole could be disconnected very rapidly, and the whole system not weigh more than 20 lbs., which is a very slight addition to the axle-mule's light load. Proposed pole draught.

A very ingenious form of carriage has recently been proposed by Major A. Clavarino of the Italian Army[1] (*vide* Plate VI.). It packs very closely on the mule. A carriage has been submitted for the 20-pr. howitzer and is under trial. In this the trail folds in the centre and the brackets can be opened out, thus bringing the weight more on to mule's sides. Proposed Italian carriage. Howitzer carriage.

Some remarks on the ammunition and small stores of a battery I am compelled, from want of space, to omit. The number of stores in a battery is already very large, and any attempt at simplification or diminution should receive every consideration. Ammunition and small stores.

The material supplied for British mountain batteries is very good and excels that of any other Mountain Artillery that I have seen. The following points however I have noted as requiring attention. Harness and saddlery.

The present snaffle bridle is not all that can be desired; the circular Newmarket bit, in use with some batteries in India, is incomparably better, the point of attachment of the rein being more practical and mules are easily led and held with them. Bits.

The crupper may, I think, be done away with, an arrangement such as that in use in the Austrian and Russian service shown on Plate VII. being substituted. With this the risk of a possible sore dock is avoided, and I have seen the system work very well in India. Cruppers.

The pannels in use are excellent, and, with ordinary care, a sore back is almost unknown. The present form of attachment to the cradle is faulty. The pannels should be frequently removed from the cradle for Pannels.

[1] Revista d'Artiglieria é Genio, December, 1885.

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repairs, cleaning and re-arrangement of stuffing. This at present is not easily done and a special tool is necessary to replace them. The Indian system of small straps running through leather patches on the pad is preferable.

Austrian pannel

Too much attention cannot be paid to the stuffing of these pannels. A sketch of the Austrian pannel[1] (Plate VII.) shows a method by the stuffing is prevented in a great measure from shifting, and as an economy of weight would probably be effected is worthy of a trial.

Cradles

The ordnance cradles made in England are some 10 to 12 lbs. heavier than those made in India, a no inconsiderable addition to the mule loads. Wood is used in both countries. Although they are thus more comfortable for the men to handle when cold or wet and more easy to repair than if made of steel, too much must not be sacrificed to obtain these points. Similar arguments, which have since proved nugatory, were, I believe, advanced against the introduction of iron carriages for Field Artillery. Personally I am in favour of the use of steel in the manufacture of cradles as being lighter, stronger, and in the case of side loads, allowing the load to be closer to the mules side.

Material for repairs

The wear and tear of mountain battery harness is immense, and a comparatively large amount of material for repairs is required for the collarmakers.

Range finder

A good range-finder for mountain service has yet to be invented. The great difficulty to be contended with is the selection of a suitable base for observation. Simplicity and strength are a *sine quâ non* for this rough service.

Tactics

Necessity of preliminary training

Success in hill warfare depends to a great extent on the marching powers of the troops, and unless their previous training has accustomed them to the exceptional exertions of mountain climbing, the best conceived tactical combinations will fail.[2] In preparing any tactical scheme great difficulties arise in arranging for the simultaneous convergence of the various columns if the ground be not previously known.

Maps

Maps, though giving the direction of the watersheds, valleys, &c., give little or no information as to the state of the paths and obstacles.

Measurement of distances

Mountain paths, says a French writer, "are not mile-stoned[3] (kilo mètres), distances in mountain warfare are measured by hours—by length of time,—it is very difficult under these conditions to form a precise idea of the speed of the march in miles."

High state of discipline necessary

It is said that mountain warfare is essentially "a war of surprises." When we consider the absence of Cavalry and the consequent proximity of the covering line of scouts the necessity becomes apparent for the very highest state of discipline and efficiency among mountain troops and the reduction to a minimum of impedimenta that may cause confusion on narrow mountain roads or delay the deployment of the rear of the columns.

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[1] Unterricht über die Beschirrung für Feld-und Gebirgs-Batterien.

[2] "Notes sur la marche"—de Pourvourville. Journal des Siences Militaires, Nov., 1886.

[3] Colonel Paquié,—"Marches en pays de Montagnes."

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Drill

The drill of Mountain Artillery is extremely simple, being confined principally to the evolutions applicable to the active service.

Pace

The pace of a mountain battery [1] is supposed to be four miles an hour, but this is seldom attained on the hill side, and if kept up for long in column of route is very fatiguing to the rear of the column. Three and a half miles is, I think, a fair average and can be kept up for a number of hours. Laden mules must only be made to trot in case of emergency, and then for as short a distance as possible. This pace must never exceed that of the double.

Marching powers

The following example of the marching powers of a mountain battery is interesting.[2] In Algeria in 1844, "a column of Cavalry and a section of Mountain Artillery at 42 leagues (126 miles) from Constantine received orders to march on that place on the 31st May . . . . the gunners and drivers were mounted on mules requisitioned from the Arabs, and at 10 a.m. on the 3rd June the entire section arrived at Constantine with the Cavalry without having a single mule disabled."

Distances taken on line of march

The tables on page 417 will show the enormous distances that must be taken up by a mountain battery on the line of march in a very rough country. It is very difficult for an escort to efficiently cover the flanks of these long columns, and I therefore recommend the arming of the gunners and drivers with pistols.

Place in column of route

The fighting line of a battery can be kept fairly compact, but deployment into position from a narrow path must take some time, and it is therefore of great importance that the guns should be as near the head of the column as possible compatible with their safety.

Massing of guns

In purely mountain warfare it is often impracticable from the nature of the ground to mass any considerable number of guns except in those decisive actions which take place in the broader valleys and lower spurs of the hills *e.g.* at Seragevo in 1878,[3] where out of 52 Austrian guns in action 32 were massed in one battery. Under these circumstances batteries have constantly to be broken up; unity of command and the control and direction of fire on a common object can only be attained by a convergence of fire directed by a well practised system of signalling, and on this account it is most necessary that the divisions of a mountain battery should be complete in themselves and that special care and attention should be paid to the training of subaltern officers and signallers.

Proportion of guns to rifles.

It is impossible to lay down a fixed proportion of mountain guns in relation to the number of rifles as is done in the case of Field Artillery; the new factor entering into the calculation being the size of the columns that it is possible to manœuvre. (The French Alpine "group" consists of four companies of 600 rifles and one battery of six guns. The proportion here being 10 per 1000).

This however may be taken for granted that, given an enemy of our own calibre the proportion of guns per thousand rifles will have to

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[1] Manual of Mountain Artillery.

[2] Memorial d'Artillerie.

[3] Organ der Militär-Wissenschaftlichen Vereine.

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be in excess of the three to four which is the usually accepted proportion for field guns. For the following reasons :—

Local action of Mountain Artillery

The action of Mountain Artillery is essentially local, *i.e.*, a force engaged in a mountain campaign is obliged to send out small columns, acting independently, to various defiles and commanding positions. The Artillery accompanying these columns cannot as a rule assist, or at most only to a small extent, that on neighbouring positions, and thus a large number of guns is necessary than would be the case if they could afford one another mutual support.

Reason for small columns

The reason for small columns is that in mountain marching the columns become unduly opened out. In order to save the rear portions of a force from the fatigue of closing up long distances, and thus prolonging the periodical halts, a considerable force marching on a single path is echelonned in several bodies forming independent columns at such a distance from one another that the stragglers from the preceeding body do not interfere with the head of the next column, but sufficiently near to each other to obviate the necessity of each throwing out an advanced guard and as far as possible to allow each to profit from the protection of the flanking parties of the head, and dispense with throwing out parties of their own. The French Alpine group is organised as one of these small columns and the main body three companies, one battery and the baggage train occupies on the line of march about 1300 yards, the fourth company being detached as advanced guard.

French Alpine group

Conduct in action

The varied nature of the ground in mountain warfare renders it difficult to lay down any specific rules for the conduct of Mountain Artillery in action without citing a great number of examples and considering many features of country. I shall however as far as space will permit venture to generalise on a few leading principles.

In all cases it is most necessary that the guns should be brought into action as early as possible and in the greatest numbers available. We will now consider both phases of the combat and take an illustrative case in which on the position to be attacked and defended, the guns are placed some 500 or 600 yards in rear of the fighting line of infantry.

Offensive 1st position

Offensive. The first position of the guns will vary between 2500 and 3000 yards, if the ground admit of it, from the enemy's artillery position. The range being found either by range-finders or trial shots, the enemy's guns will be engaged and the deployment of the infantry covered. The hostile artillery fire having been subdued the infantry will advance, and in order that they shall not mask the fire of the guns and that the latter may be well up in preparation for the final phases, the guns will be advanced some 500 to 900 yards, thus bringing them 1400 to 1500 yards from the enemy's infantry line, at which range they should be able to inflict great damage on it by shrapnel fire and at the same time be outside the dangerous zone of the enemy's rifle fire. After having thus prepared the attack and the attacking infantry having arrived at some 600 to 700 yards of the defending infantry line and thus again commencing to mask the assisting artillery fire the guns will again advance to about 800 yards from the enemy's

2nd position

3rd position

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infantry position and commence as hot a fire of shrapnel as possible to cover the final movements before the assault. Under certain conditions the guns may be allowed to advance from the first position to 800 yards at once. They will here afford an immense moral support to the attack. In this position if the defence allow their rifle fire to be drawn off on to the guns they will commit a fatal mistake, for it will encourage the attacking infantry at a period when their hearts are most likely to begin to fail them.

Assault

During the actual assault the guns must move into 400 yards, or closer if there appears to be any chance of failure, and cover the movement with a crushing fire of case and reversed shrapnel. Immediately their fire is masked, by the infantry rushing into the position, they must limber up and move on to it to resist a counter attack and prevent the enemy making a stand on a more retired position by keeping him on the move and trying to turn his retreat into a rout.

Object of attack

Mountain gunners must remember that they can go wherever an infantry soldier can without the assistance of his hands and knees, and above all they must remember that the object to be attained in an attack is that the decisive arms, viz., the two infantries may be brought together in close combat. To achieve this end the auxiliary arms especially the artillery must devote all their attention, very often at the great sacrifice to themselves in men and sometimes in guns, but final success is cheaply obtained even at this price.

Movements under fire

Movements under fire may be made with less loss than is generally imagined, as Mountain Artillery can very readily take advantage of irregularities of ground.

Defensive

Defensive. The artillery of the defence is often at a great advantage in engaging at previously ascertained ranges. Should the artillery of the attack be worsted in the preliminary contest it is probable that the attack will only be delivered, if at all, in a half-hearted way and at least with the elements of reverse, though the engagements of 1866 exhibit some brilliant exceptions. Should however the attacking artillery be successful at first, that of the defence must content itself with refitting as well as possible, taking advantage of those moments when the enemy's guns are on the move or masked by the advancing infantry, and reserve themselves for a final self-sacrifice in covering the retreat or retrieving the fortunes of the day by a sharp counter attack.

Object of defence

The point to be kept in view all through a defensive action is that the attacking infantry must be prevented from delivering an assault. It therefore should be the object of artillery fire whenever it presents a suitable target even though the guns by firing on it should be unable to reply to the attacking artillery. Holding this in view the position of the artillery of the defence is marked by those places from which the guns can sweep and if possible enfilade any strongly marked avenues of approach.

Fire discip line

In purely mountain warfare the artillery combat will be as a rule between very small numbers of guns, and the regulation of the fire must be extremely strict. The difficulties of transport render it imperative that not a round should be wasted, and for this reason

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skilful range-finders and a well-trained gun detachment are a *sine quâ non*. No ammunition should be thrown away by firing salvoes, for be it remembered that we are not dealing with the fire of a mass of guns but only that of a small number where every shot must be made to tell. In the larger actions in the broad valleys a more ample supply of ammunition may be expected with the larger masses of troops and the increased facilities for transport. Here the firing of salvoes may, under certain conditions be permitted. The regulation and the division of the fire of these large masses of guns is practically the same as that for Field Artillery, requires much space for its adequate discussion and is I take it, beyond the scope of this essay.

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APPENDICES.

Service Batteries.—Detail of Proposed Establishments.

	MEN.									HORSES.								
		A.		B.		C.		D.			A.		B.		C.		D.	
	Peace.	Addition for War.	Total, War.	Addition for War.	Total, War.	Addition for War.	Total, War.	Addition for War.	Total, War.	Peace.	Addition for War.	Total, War.	Addition for War.	Total, War.	Addition for War.	Total, War.	Addition for War.	Total, War.
OFFICERS.																		
Major	1	—	1	—	1	—	1	—	1	1	—	1	—	1	—	1	—	1
Captain	1	—	1	—	1	—	1	—	1	1	—	1	—	1	—	1	—	1
Lieutenant ...	3	—	3	—	3	—	3	—	3	3	—	3	—	3	—	3	—	3
N.-C.-O.'S AND MEN.																		
Sergt.-Major ...	1	—	1	—	1	—	1	—	1	1	—	1	—	1	—	1	—	1
Qr.-Mr. Sergt. ...	1	—	1	—	1	—	1	—	1	1	—	1	—	1	—	1	—	1
Sergeants	6	—	6	—	6	—	6	—	6	—	—	—	—	—	—	—	—	—
Corporals	6	—	6	—	6	—	6	—	6	—	—	—	—	—	—	—	—	—
Bombardiers ...	6	—	6	—	6	—	6	—	6	—	—	—	—	—	—	—	—	—
Trumpeters ...	2	—	2	—	2	—	2	—	2	2	—	2	—	2	—	2	—	2
Gunners	90	—	90	—	90	—	90	—	90	—	—	—	—	—	—	—	—	—
Drivers	60	—	60	—	60	—	60	7	67	—	—	—	—	—	—	—	—	—
" Mounted	3	3	6	—	Withdrawn in B, C & D					6	6	12	Withdrawn in B, C & D.					
Muleteers	—	45	45	56	56	67	67	100	100	—	—	—	—	—	—	—	—	—
ARTIFICERS.																		
Farrier	1	—	1	—	1	—	1	—	1	1	—	1	—	1	—	1	—	1
Collar Makers ...	3	—	3	—	3	—	3	—	3	1	—	1	—	1	—	1	—	1
Wheelers	3	—	3	—	3	—	3	—	3	—	—	—	—	—	—	—	—	—
Shoeing Smiths	2	—	2	—	2	—	2	—	3	—	—	—	—	—	—	—	1	1
HORSES.																		
Spare	—	—	—	—	—	—	—	—	—	—	1	1	1	1	1	1	1	1
Totals ...	*189*	48	*237*	56	*242*	67	*253*	107	*294*	*17*	7	*24*	1	*12*	1	*12*	2	*13*

	MULES.								
MULES.									
1st Line	39	6	45	6	45	6	45	—	39
2nd Line	36	6	42	6	42	6	42	—	36
3rd Line	16	6	22	6	22	6	22	14	30*
Baggage	—	—	—	31	31	60	60	63	63
4th Line	—	—	—	—	—	—	—	28	28†
Totals ...	*91*	18	*109*	49	*140*	78	*169*	105	*196*

The above Table shows Establishments for War in Countries, as follows:—

A. Where roads are available.
B. No roads. Temperate climate.
C. " Hot Climate.
D. " Tropical Climate. Indian and similar service far from base.

* Ammunition Line. † Artificers and Spare.

Baggage Mules Scale **B** and **C** for distribution as follows:—

	B.	C.
Officers	2	4
Men's kits	15	30
Cooking pots	3	3
Stores	4	8
Office	1	1
Veterinary Stores		1
Water	—	6
Charcoal	—	1
Spare saddled	6	6
Total	31	60

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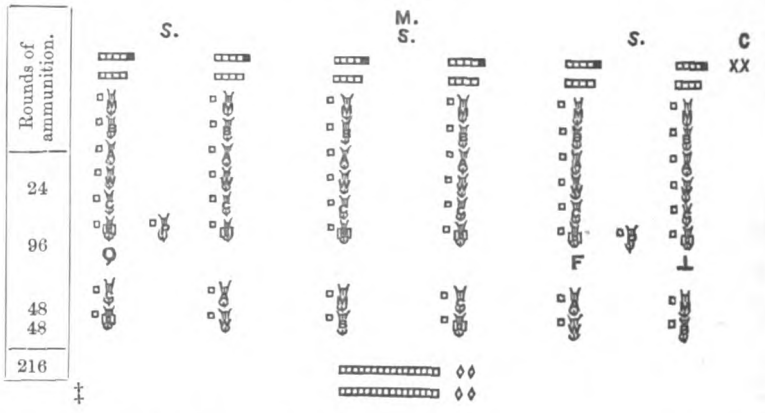
PROPOSED MOUNTAIN ARTILLERY DEPÔT BATTERY.

2·5-INCH GUN.



Officers.		
Major	1	
Captain	1	
Lieutenants	3	
Total	5	5
N.-C.-O.'s & Men.		
Sergeant-Major	1	
Qr.-Mr.-Sergt.	1	
Sergeants	6	
Corporals	6	
Bombardiers	6	
Trumpeters	2	
Gunners, Drivers	118*	
Total	140	140
Artificers.		
Farrier	1	
Shoeing-Smith	1	
Collar-Makers	2	
Wheeler	1	
Total	5	5
Grand Totals	Men	150

Horses.		
Major	1	
Captain	1	
Lieutenants	3	
Sergeant-Major	1	
Qr.-Mr.-Sergeant	1	
Farrier	1	
Trumpeters	2	
Total	10	10
Mules.		
Gun	12	
" Relief	4	
Axle	6	
" Relief	2	
Wheels	6	
" Relief	2	
Carriage	6	
" Relief	2	
Ammunition	6	
" Relief	2	
Pioneer	2	
Total	50	50
Animals		60

Saddlery.	
Officers	5
Universal	5
Pack Saddles — Ordnance	48
Baggage	22†
Total	80
Ammunition.	
Rounds per Gun — shell — common	8
shrapnel	22
shot, case	6
Total per Gun	36
" " Battery	216

* Plus 30 for every Battery in excess of 5 to be supplied from this Depôt.

† 2 for Pioneer Tools. Remainder in charge of Sub-Divisions to bring 1 Division to War Strength of Baggage Mules as required for instructional purposes.

‡ For explanation *see* bottom of Plate II.

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Depôt in War to become 2 Artillery and 1 Infantry Ammunition Columns.

Staff.	Number.	Horses.		1st Artillery Column.	2nd Artillery Column.	Infantry Column.	Horses.	Grand Total.
Major	1	1	Lieutenants	1	1	1	3	—
Captain	1	1	Sergeants	2	2	2	6	—
Sergt.-Major	1	1	Corporals	2	2	2	—	—
Qr.-Mr. Sergeant ...	1	1	Bombardiers	2	2	2	—	—
O. S. Conductor	1	1	Drivers	56	56	56	—	—
Trumpeters	2	2	Wheelers	1	1	1	—	—
Farrier	1	1	Collar-Maker	1	1	1	3	—
Servants and Drivers	12	—	Shoeing-Smith	1	1	1	—	—
Baggage Mules	6	—	*Mules.*					
			Ammunition	80	80	80	—	—
			" spare ...	6*	6*	6*	—	—
			Baggage and Store ...	11	11	11	—	—
			" spare	1†	1†	1†	—	—
Total Men	20	—	—	66	66	66	—	218
" Horses ...	—	8	—	4	4	4	12	20
" Mules ...	6	—	—	98	98	98	—	300

Addition required.

Men	68
Horses	10
Mules	250

Ammunition carried.‡

Shell, { common	640
{ shrapnel	1600
Shot, case	320
Cartridges	2560
Small Arm Ammunition Boxes ...	160

* 4 Saddled, 2 Bareback. † Saddled. ‡ With proportion of Tubes and Fuzes.

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Establishments, &c., of European Mountain Batteries.

	ENGLAND.		AUSTRIA.				FRANCE.						ITALY.			RUSSIA.			SPAIN.					SWITZERLAND.	GREECE.	PROPOSED ENGLISH.						
							ALGERIAN.				HOME.								Battery.							DEPOT.		SERVICE BATTERY				
	War.		Peace.		War.		War.				War.		War.			Peace.	War.									Peace.	War.	Peace.	War Scale.			
			Normal.	Increased.	Mixed.	Normal.	Battery.	1st Artillery Ammunition section.	1st Infantry Ammunition section.	Total Battery.	Battery.	Artillery Ammunition section.	Battery.	Artillery Ammunition section.	Total Battery.	Normal.	Increased.		Peace.	War.	6th Battery of Brigade converted in War into 2 Artillery and 1 Infantry ammunition columns.	Cadre of Depôt.	War.	War.			2 Artillery, and 1 Infantry Ammunition Columns.		A.	B.	C.	D.
Nature of Gun	2·5″	7-pr	7cm Bronze.				8cm Steel.						7·5cm Bronze.			3-pr. Bronze, and 2·5″ Steel.			8cm Steel.					7·5cm	7·5cm	2·5″ R.M.L. Jointed Gun.						
Number of Guns	6	6	4	4	4	4	6	—	—	6	6	—	4	—	4	4	4	8	4	6	2	—	—	6	6	6	—	6	6	6	6	6
,, Officers, N.-C.-O.'s & Men.	294	—	94	68	103	111	—	—	—	229	—	—	154	51	205	155	251	3-pr 305 / 2·5″ 322	114	197	61	173	16	170	—	150	218	189	237	242	253	294
Animals.																																
Riding	13	—	4	4	4	4	—	—	—	21	—	—	8	2	10	7	7	† 7	9	11	3	8	5	12	—	10	20	11	12	12	12	13
Pack...	172	—	8	18	46	61	56	41	21	118	46	—	55	31	79	24	59	† 161	30	56	15	200	—	170	64	50	279	91	109	122	151	172
,, spare	24	—	1	2	2	2	—	—	—	10	—	—			7	3	6	† 19	3	14	—		—	—	—	—	21	6	12	18	18	24
Carts and Wagons.																																
2-horse	—	—	—	—	2*	—	—	—	—	—	—	—	—	—	—	2‡	5§	—	—	—	—	—	—	—	—	—	—	3*	—	—	—	—
3 ,, ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—			—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4 ,, ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—			5§	—	—	—	—	—	—	—	—	—	—	3*	—	—	—
6 ,, ...	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ammunition.			War 1st Line		2nd	Total.																										
Shell, { common	144	—	48		144	192	240	240	—	480	184	296	210	180	390	—	—	336	120	300	60	—	—	600	480	48	640	102	138	138	138	144
Shell, { shrapnel	360	—	64		160	224	120	120	—	240	92	148	210	180	390	—	—	336	96	240	48	—	—	—	240	132	1600	294	390	390	390	360
Shot, case	100	—	16		16	32	60	60	—	120	46	74	24	—	24	—	—	112	24	60	12	—	—	—	6	36	320	40	52	52	52	100
Total per Battery... ...	604		128		320	448	420	420	—	840	322	518	444	360	804	—	—	784	240	600	120	—	—	600	726	216	2560	436	580	580	580	604
,, Gun	100		32		80	112	70	70	—	140	54	89	111	90	201	—	—	98	60	100	60	—	—	100	121	36	—	72	96	96	96	100
Star Shell per Battery..	18	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	21	21	21	21	18

* Animals for these included above. † The number of Baggage Mules varies considerably according to local circumstances. ‡ Provision Wagons. § 1 Treasure and Office, 2 Provision, 1 Tent, 1 Ambulance Wagon. For detail Russian Battery, see p. 404. ‖ Plus 98 rounds in Divisional Flying Park.

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Mountain Guns of Europe.

	Gun.		Bore.			Diameter, powder chamber.	Rifling.					Shell.					Shot.		Powder charge.	Velocity.		Gun and Carriage.	
			Length.						Grooves.			Common.		Shrapnel.			Case.						
	Total weight.	Length.			Calibre.		Twist.	Length.	Number.	Depth.	Width.	Weight, empty.	Bursting charge.	Weight, empty.	Bursting Charge.	Number of bullets, &c.	Weight.	Number of bullets, &c.		Muzzle.	At 1000 yards.	Total weight.	Carried by
	lbs.	ins.	ins.	cals.	ins.	ins.	cals.	ins.		ins.	ins.	lbs.	ozs.	lbs.	ozs.		lbs.		ozs.	f.s.	f.s.	lbs.	Animals
England { heavy	400	70·45	66·5	26·6	2·5	2·56	80 to 30	54·73	8	·05	·51	7·25	4	7	·5	121	6·75	162	24	1140	1028	943	5
England { light	200	41	36	11·3	3	3	20	34	3	·1	·6	6·89	6·5	6·8	·5	42	6·25	70	12	968	786	550	3
Austria	196·9	39·37	32·85	8·71	2·598	2·755	30	23·8	18	·049	·335	6·142*	2·09	7·03	1·25	73	6·92	48	12·3	978	791	437	2
France	231·4	47·24	37·7	12	3·14	3·14	72	29·9	24	·039	·314	12·3	8·46	12·3	5·4	93	12·3	85	14·1	843	730	672	3
Italy	214·9	39·3	35	8·9	2·9	3·1	46	25·9	12	·051	·559	9·0*	4·9	8·9	0·45	103	9·0	126	10·6	935	770	526	3
Russia { bronze	212	29·5	24	8	3	3·149	35	13·4	12	·05	·6 to ·5	8·8	5·4	10·6	1·3	70	7·36	48	12	697	579	538	3
Russia { steel pattern, 1883	217	39·8	33·6	—	2·5	—	40 to 20	—	20	—	—	8·8	4·35	—	—	—	—	—	13·5	932	760	—	4
Russia { Baranoffski... ...	217	47·6	42·1	16·84	2·5	2·59	30	35	20	·024	·7 to ·64	9·1*	2·06	9·1	·35	88	8·73	41	13·5	950	772	638	4
Spain	224	37	33	10·9	3·1	3·3	46	24	12	·045	·64	8·3*	6·1	10·29	1·34	90	7·36	48	14·1	961	760	600	3
Switzerland	231	37·6	31·4	10·8	2·9	—	35	24	24	·049	·27	9·3*	3·05	—	—	—	—	—	14·1	899	758	551	3

Servia.—Bronze R.M.L. Guns, and a few 7cm steel Krupp Guns.
Norway.—3-inch R.M.L. iron.
Greece.—7·5cm R.B.L. steel Krupp.
Turkey.—7cm R.B.L. steel Krupp.
Portugal.—8cm R.M.L. bronze.

* Ring Shell.

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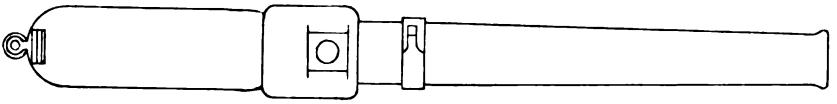
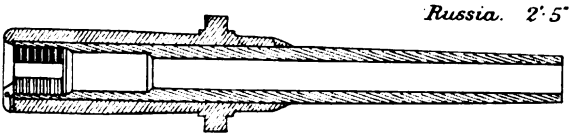
MOUNTAIN GUNS OF EUROPE.

England. R.M.L. 2·5" jointed. Steel.

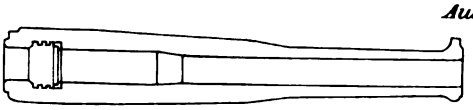


Russia. 2·5" "Barranoffski." Steel.

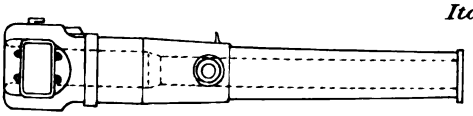


France. 3·14" Steel.

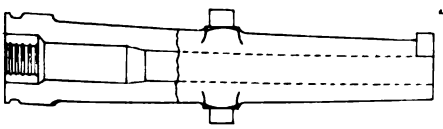
Austria. 2·6" Steel-Bronze.



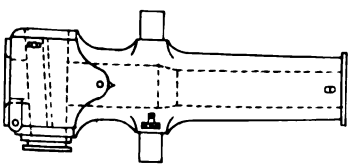
Italy. 2·9" Steel-Bronze.



Spain. 3·1" Steel.



Russia. 3" Bronze.



Scale. R.F. $\frac{1}{8}$

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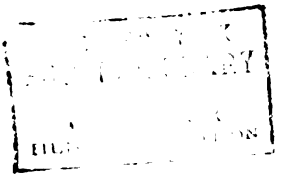

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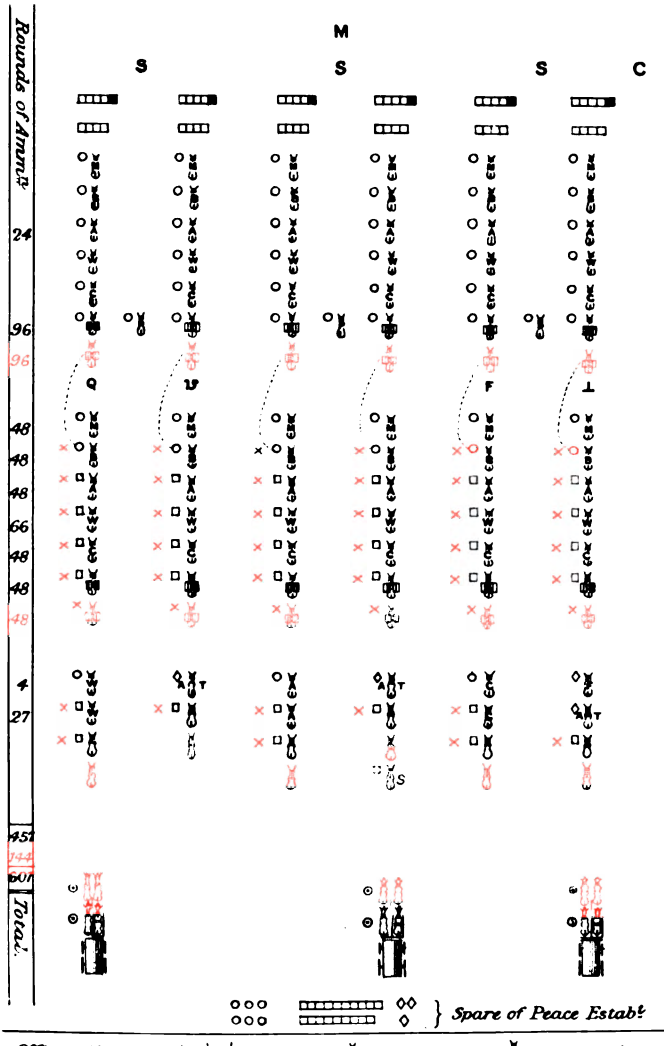
PEACE AND WAR EST.ts OF BATTERY AS PROPOSED IN TABLE A.

2·5 in Gun. Subdiv.ns and Lines at Half Interval.



Officers & Mounted men	11		Mules	Gun Chase	12	Forge	1
■ Sergeants.	6			" Breech	12	Artificers	3
□ Corp.ls Bomb.rs & Gr.s	102			Axletree	14	Pioneer	3
⊖ Mounted Drivers.	3	3		Wheels	14		
○ Dismounted "	60			Carriage	14	S. Spare Horse led by Spare GT	
◇ " " Artificers	7			Ammun.n	12+2		
× Muleteers.		45		Spare. Bareback	6+6		
GRAND TOTALS.	Men.	189	48	237.	91+18 = 109.	Horses 17+7 = 24.	

Peace Est.t Black. Add.ns for War Red. Gunners leading Mules in Peace become Spare and are replaced by Muleteers in War. Relief Gun Breech Drivers Peace go to 2nd Ammun.n Mules 1st Line in War.

Batteries as proposed in Tables B *and* C *are similar to the above except that the Waggons of the 4th line are replaced by Baggage Mules.*

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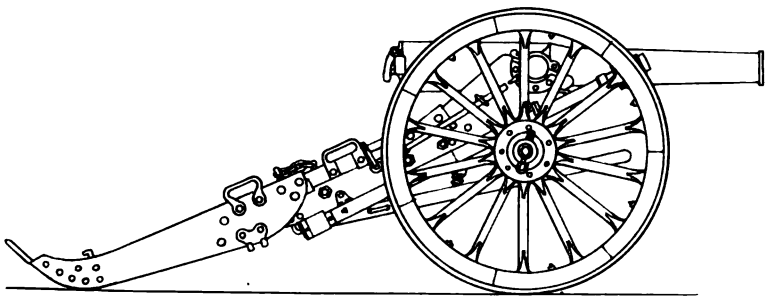
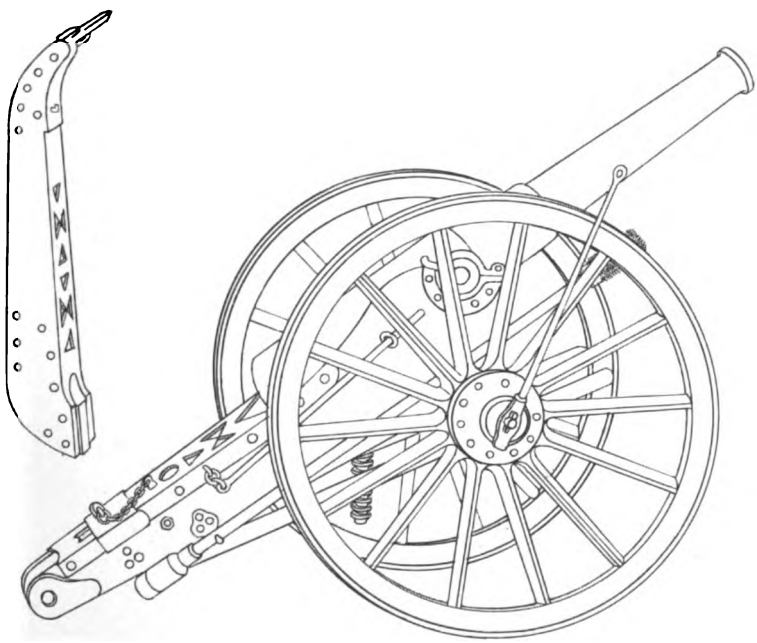
FRENCH MOUNTAIN CARRIAGE.

The same divided for High Angle Fire.





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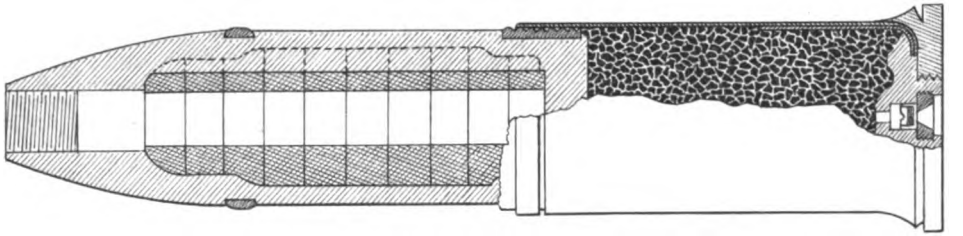
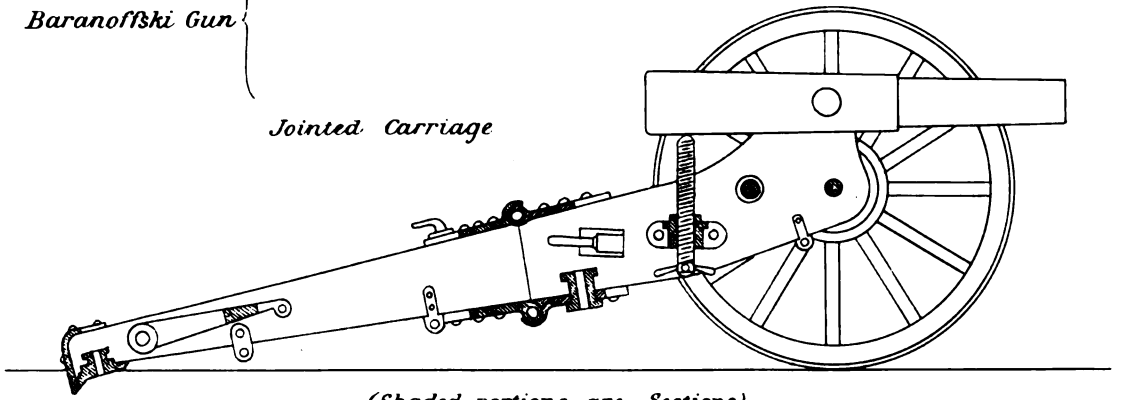
RUSSIA.



Ammunition (Ring Shell)

Baranoffski Gun

Jointed Carriage



(Shaded portions are Sections)

PL IV.

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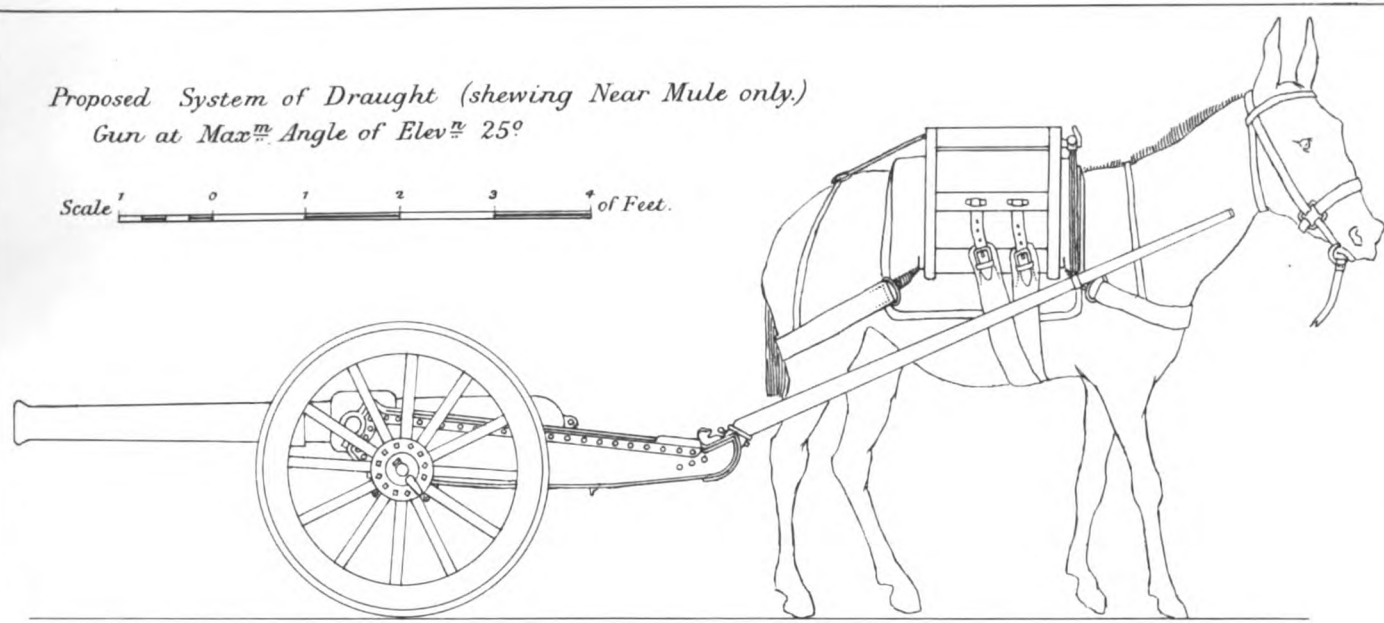
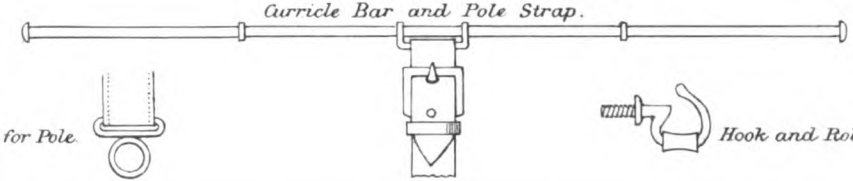
Vincent Brooks Day & Son, Lith.

Proposed System of Draught (shewing Near Mule only.)
Gun at Max^m. Angle of Elev^n. 25°

Scale 1 0 1 2 3 4 of Feet.



Carricle Bar and Pole Strap.



Swivel and Band for Pole.

Hook and Roller for Cradle.

P.IV.

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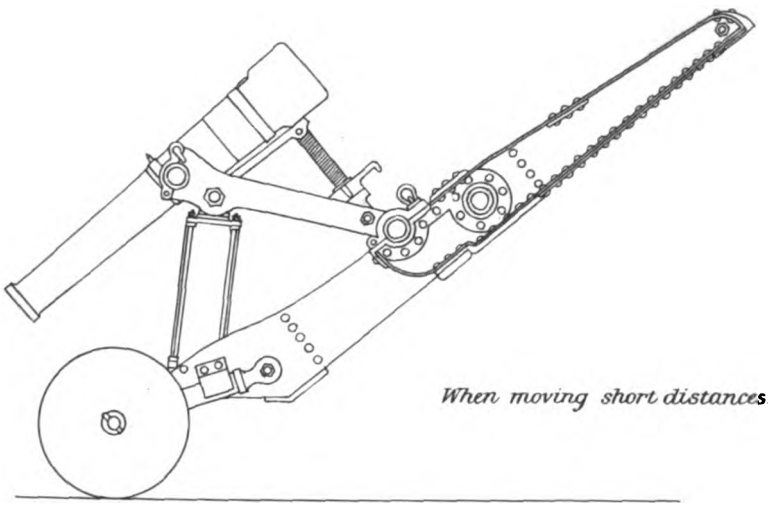
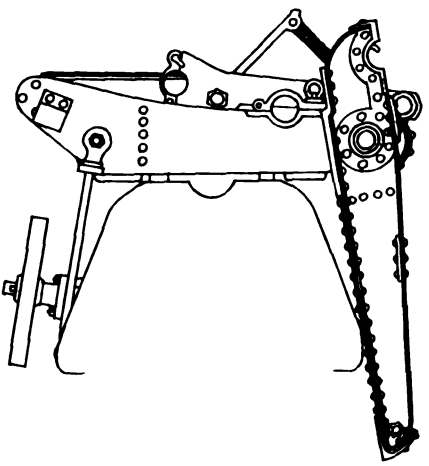
MAJOR CLAVARINO'S PROPOSED MOUNTN CARRIAGE.



When moving short distances.



Packed on Mules back.

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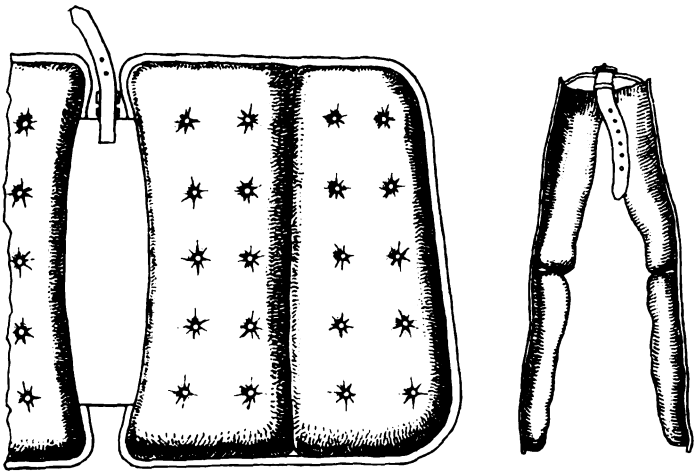
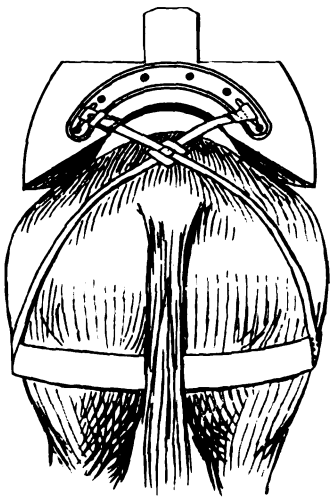


Austrian pannel.



Rear View of Austrian Pack Saddle.
shewing absence of Crupper.

The Russian arrangement is similar.

Vincent Brooks, Day & Son, Lith

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A METHOD
OF
MOUNTING AND DISMOUNTING
THE
LIGHTER PIECES OF FIELD ARTILLERY ORDNANCE.

BY
LIEUT. D. G. PRINSEP, R.A.

THE following method of mounting and dismounting guns of Field Artillery is, I believe, not unknown; but with our more modern guns with long chases it would seem to be quite as quick, and more preferable to the usual method; and it obviates the necessity of digging a hole in the ground for the muzzle. (*Vide* § 10, Part II., Field Artillery Exercises).

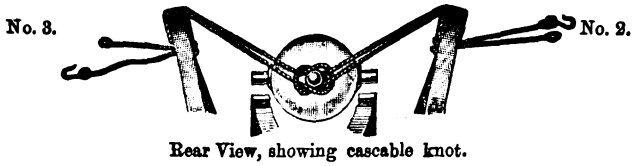
By the following method the gun is raised out of its trunnion holes easily, and quietly lowered to the ground, and is kept horizontal all through the process.

Guns can also be dismounted or mounted without unlimbering should such an occasion present itself.

The stores required are two drag ropes and a handspike, all of which are carried with the subdivision.

I have only tried it with M.L. guns but there would, I think, be no difficulty in its application to breech-loading ordnance.

1ST CASE.—*When in Action.* On the word of command "Prepare to dismount the gun," the usual duties are performed by the detachment, but in addition, Nos. 4 and 5 remove the inner stanchions of the axletree seats and No. 8 brings up a second dragrope. Nos. 7 and 8 tie a reef knot with the bights of the two dragropes in the centre, and then pass the centre of the knot over the cascable.—*See Figure.*



Rear View, showing cascable knot.

Nos. 2 and 3 take the two ends of their respective dragropes and stretching them as taut as possible horizontally, take two turns round the felloes of the gun wheels, passing first over the tire and then round, and then one turn round the nearest spoke and hold on.

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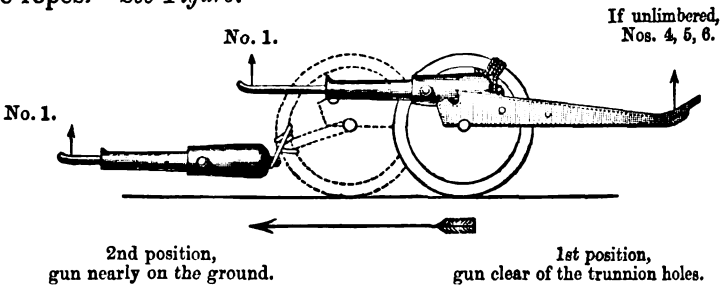
No. 1 takes the handspike, double-manned by 7 if necessary, inserts it into the bore a short distance, and prepares to lift at the end of it.

On the word "Lift, and run the carriage forward," Nos. 1 and 7 lift at the muzzle, and Nos. 4, 5, and 6 raise the trail, so that the weight of the gun is taken by the ropes at the breech and the men on the handspike at the muzzle. Nos. 8 and 9 man the wheels together with 2 and 3, but the latter must not leave go their hold on the ropes.—*See Figure.*



As the carriage is run forward, the wheel purchase raises the breech of the gun and the trunnions out of the trunnion holes, moves the gun forward, and gradually lowers it to the ground clear of the front of the carriage. Nos. 1 and 7 also lower the muzzle gradually, so as to keep the gun horizontal. The carriage can then be dismounted in the usual way and the limber backed over the gun to sling it if required.

2ND CASE.—*When limbered up.* The same process is gone through, but no men are required at the trail, as the wheel horses give the necessary power. They must be steadily backed. Four numbers only are necessary, viz., two at the muzzle handspike and two on the dragropes, one each side. The lift out of the trunnion holes is less and a good deal easier in this case.

In both these cases, mounting the guns is exactly the converse of the foregoing. Two dragropes are used so as to allow an ample margin of safety. They take the weight at an inclination of between 25° and 30° to the horizontal.

The weight on the muzzle handspike varies with the gun but is not too great for two men; with the 9-pr. of 6 cwt. one man is sufficient.

For instance, assuming there is 3 feet of handspike between the muzzle and the point where the men lift and as a rule there would be more than 3 feet—

In the 9-pr. of	6 cwt.	.....	168 lbs.	would have to be sustained by the muzzle numbers.		
" "	8 "	.....	224 lbs.	"	"	"
" 16-pr. of	12 "	.....	319 lbs.	"	"	"

HILSEA, COSHAM,
May 10th, 1887.

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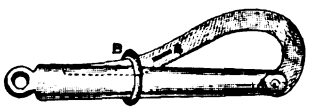
A NEW SLIP TRACE HOOK.

BY

MAJOR G. R. GAMBIER, R.H.A.

To any Horse Artilleryman who likes to manœuvre his battery at a gallop, perhaps one of the most exasperating incidents which can occur, is that of a trace coming down. With the present Service slip

SERVICE SLIP TRACE HOOK.
A pin acting as hinge. *BB* slots for tie.



hook this must occur frequently, for if the tie breaks the hook must fly open. It is very evident to all who know what would constitute a good slip hook, that one point should be a *sine quâ non*, and that is that there should be no strain upon the tie; theoretically there is supposed to be none in the Service hook, practically there is a great deal because the point of the hook jerks up against the iron ring, and the ring is only kept in its place by the tie. I beg now to submit for the approval of my brother officers a hook which can never come undone in the first place, and which when required to be undone in case of an accident (a not very unfrequent occurrence) is easier undone than the Service hook, which I have found more than once jam by the great pressure brought to bear on the ring.

NEW SLIP TRACE HOOK. *Closed.* *Open.*

The principle of this hook was invented by Farrier-Sergeant Meiklejohn, A/11, R.A., in 1874: it has since been improved upon by me, and further improved, by abolishing the tie altogether, by Sergeant-Farrier MacNeil, E/A, R.H.A., who substituted a spring; in case the

WITH SPRING *A*. *BB* SLOTS FOR TIE.

spring breaks (which I have not yet known it do) there is the same

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arrangement ready prepared for the tie. This hook alone is used in the gun teams of E/A, R.H.A., and since its adoption I have not known a single trace come down.

If the drawing is examined it will be seen that the hook cannot get broken or bent and is immensely strong. The Service hook, of which I attach a drawing, most evidently is much weaker, as a part of the strain is on the small pin which acts as a hinge; the tie, too, is exposed to a severe strain, and the ring can get jammed when the point of the hook is pressing against it, as occurs when a horse is down.

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IMPROVEMENT

IN THE

ROYAL (GARRISON) ARTILLERY.

BY

MAJOR F. C. MORGAN, R.A.

It is a common supposition, and we hope not entirely a fallacious one, that there exist somewhere hidden away amongst the archives of the War Office, detailed and elaborated schemes to meet every contingency that may arise in any fortress or military station of the British Empire, in the event of hostilities with any first-rate power. In fact, that in order, so to speak, to place on a war footing any particular fortress or fortified place of our vast dominions, it would only be necessary to transmit to the commander of such place, the scheme previously prepared. And in addition to despatch a few shiploads of stores and equipment such as would be required to fully carry out the plan of action, but which for divers reasons it had not been deemed expedient to store on the spot beforehand.

Whether such supposition is correct or not, it might perhaps be wiser to assume that on the outbreak of war, the elaborated scheme, as divulged to the commander of any particular fortress, would be fully contained in the order to "carry on as best you can with the means at your disposal." At any rate it will be conceded that the commander who acts upon this assumption in time of peace will be in the best position to fight his fortress under any circumstances.

Are then the training, instruction, &c., of the Artillery of every fortress as complete as existing circumstances permit, and is everything so arranged in every fortified place that its commander can rest confident that if he fails hereafter to successfully resist an enemy, it will not be owing to defects in any of the above, but due to other causes over which he has had no control, such as inferiority of armament, paucity of men, &c.?

The writer of a recent excellent prize essay on "The Arrangement and Working of the Artillery Defence of a Fortress," has elaborated the plan of defence as it would be carried out were the necessary appliances in existence on the spot, and were there present officers and men who had previously had constant training in these appliances.

Let us however look at things as they are, and consider if with the means at our disposal we cannot make more perfect arrangements to obtain a maximum of strength out of our men and *matériel*.

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With regard, then, to the training of our Garrison or Fortress Artillerymen.

Considering, firstly, a battery as constituted, it would apparently be of the greatest advantage to classify its gunners according to the knowledge and experience of the practical part of artillery science which they possess. And in the case of non-commissioned officers, to insist on artillery knowledge being one of the essentials to advancement.

It is doubtless of great importance that the men should be classified according to their moral characters and also as to their degree of knowledge of the three "R's," but in time of need it would, in very many cases at any rate, be of more importance to know those upon whose practical knowledge of their business dependence could be placed. For this latter purpose then, no proper system of classification exists, and it is thought that gunners after passing the recruit stage should be rated in three classes; and that a slight increase of pay should be allowed in each class, in order to encourage a man to gain a knowledge of his duties as an artilleryman.

In bygone days a garrison artilleryman usually served for a longer period than now, and had in reality very little to learn, consequently his degree of training was not so important a factor as it is now. In the present advanced—and always advancing— artillery age, a man is literally overwhelmed with the amount of knowledge required of him, and owing to this and various other causes he knows very little. The principle of these causes are probably—1. There is very little system in the training and instruction. 2. The gunner finds that increase of pay, employment, and advancement to non-commissioned rank is chiefly dependent on qualifications other than those pertaining to a knowledge of artillery duties.

A classification then might be made somewhat on the following principles :—

Recruit Class. After a maximum term of six months in this class; the recruit having satisfactorily passed through the ordinary marching and carbine drills, and the drills of the 64-pr. gun, or a gun of about that weight, and practice from the same, would be placed in Class III. on a higher rate of pay, 1d. or 2d. per diem more, his pay whilst a recruit being rather less than at present. Should he fail to pass into Class III. at the end of six months he should be either discharged or drafted into another branch of the service for which he might be considered more fitted.

Class III. In this class the gunner would be taught :—

1. The drills and exercises of such heavy guns up to 12·5-in., about, as means existed for his instruction.
2. Operations of moving, mounting, dismounting ordnance up to 12 tons, at least, by various means.
3. A good general knowledge of all ammunition.

Having passed a satisfactory test both practically and by written questions in these subjects, he would be passed into Class II. at a higher rate of pay (1d. or 2d. per diem additional).

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Class II. In this class he would be taught:—

1. Laboratory operations, such as making up cartridges, and filling shell, heading and unheading gunpowder barrels, &c., and all the practical duties of magazine men and a general knowledge of the nature of explosives, and of the precautions necessary in dealing with them.
2. He would receive more detailed instruction in ammunition of all descriptions.
3. Instruction in the methods of removing and replacing the fittings of guns, carriages, and platforms.
4. Further detailed instruction in laying at fixed and moving objects; the instructional target being largely used for this purpose; a record being kept of each man's capabilities in this respect, great importance being attached to the desirability of every man being able to lay a gun fairly well, at any rate.

Having passed a test in these subjects he would be advanced into Class I. at a higher rate of pay (2d. per diem additional).

Class I. This class would consequently consist only of well-trained men, and a good character and certificate of education should be obligatory for admission. All full and acting non-commissioned officers would be appointed out of this class, by selection, and after passing a further examination. Range and position finding, signalling, and other special matters would be learnt.

It might be objected that by this system the whole battery would be undergoing instruction and the ordinary daily routine of work would be interfered with. This would not be at all necessary, provided that in every garrison it was ruled that gunners were not to be employed on duties other than those pertaining to artillery work.

It would only be necessary for the battery to keep a daily record of the work or drill in which every man had been employed, and in detailing the men, to ensure that each had an opportunity of a certain number of days or hours attendance at those duties, in which he would be called upon to be proficient, before passing into a higher class, at a higher rate of pay. Work and instruction would thus go together and the work would be better done.

Non-Commissioned Officers.

A sergeant should be placed in charge of each section or fourth part of a battery. Promotion to sergeant being dependent on passing a special examination, which would be waived only in the event of the man having obtained a gunnery certificate.

With regard to the latter the long course of gunnery should be shortened to six months, and young non-commissioned officers should be sent through as a rule, and the course arranged for Garrison artillerymen only. The course for Horse and Field non-commissioned officers being entirely separate.

Under each sergeant in each section of the battery, there should be

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a corporal, whose duties would be more particularly to drill squads at their daily instructions and replace the sergeant in charge of the section when necessarily employed on regimental or garrison duty. The sergeant and corporal should never be both away from their section, unless from sickness. A bombardier and two acting bombardiers should be appointed to each section.

Including the sergeant-major and pay-sergeant there would be six sergeants as at present on the strength of a battery, and the 5th corporal and 5th bombardier, not accounted for above would be the juniors of that rank, and would take the place of their equivalents in any section when necessary or perform any duties required of them, being absorbed in their turn into a section.

Officers.

In the case of lieutenants, two should always be present with a battery, each in charge of and entirely responsible for his half battery. They should carefully supervise the instruction of their men, and also be responsible for the record of the work in which each man is daily employed. When actually present with their battery they should receive a daily allowance (additional) of 2s. per diem.

Captain.—He should be responsible more especially for the drill and instruction of the battery; and be required to give a certain number of hours of theoretical instruction weekly himself in the lecture room. It should be provided as far as possible that the Captain should possess a gunnery certificate, in which case he should receive a daily additional allowance of 2s. 6d. a day and forage for a horse. The position of Captain of a Garrison battery would then be more valued than at present, and the pay more in proportion to the responsible duties he would be called upon to perform.

Major.—When actually in command of a battery he should receive 3s. a day command pay.

It is believed that only by some such means as these, can Garrison batteries be officered by willing hands, taking into consideration the obvious advantages officers of the other branches of the artillery possess over their brethern in Garrison batteries.

With a view to prevent the interruption caused to any system of proper instruction, &c., when officers are constantly changing and for other reasons not touched upon, it should be a rule that when once an officer has joined a battery in any rank, he should remain with it at least two years without exchanging.

In order to secure a uniform system of good instruction throughout, there should be drawn up two text books, one a manual of drills and exercises; the other a manual of *matériel*. The latter containing in a clear and concise manner all that a practical artilleryman should know on that subject.

To every battery a room should be allotted as an instruction room, which should be provided with models, diagrams, books, &c. It is more than probable that as soon as non-commissioned officers and men began to see the practical advantage to themselves of acquiring

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knowledge they would constantly make use of such a room in their leisure time also. All drills and exercises should be arranged so as to interest the squads as much as possible, and with this view, all drills of *trained men* should be an exact rehearsal of what would take place on actual service. It is frequently a matter of complaint, that the men do not know their drill owing to their being so frequently employed in other duties. But is it not possible to render gun drill of more value and more interesting to a detachment by imparting to it more varied instruction? Ordinarily the gun is loaded, run up, laid, and fired, and a "change rounds" take place, when the same is repeated over and over again, until the welcome order to replace stores puts an end to what in many cases has been a pure farce. In fact such drill is applicable only to recruits. In the case of drill for trained men the following details would probably assimilate the drill more nearly to actual service:—

The gun detachment should be composed only of such numbers as work at the gun: an ammunition detachment also under a non-commissioned officer should be told off for one, two, or more guns, according to the construction, &c., of the battery and ammunition stores. The strength of the latter and also the duties of each number, which must vary in each battery, or work, being written up on a board in every battery, the strength and duties of the gun detachment for each being also posted up.

With regard to the gun detachment, it should be decided beforehand what trained number is to succeed No. 1 in the event of accident. Changing rounds, except for elementary drill in slow time for recruits and partially trained men, should be seldom carried out, and it would be preferable in the case of a battery having charge of a certain portion of the defence of a work that every man should have a specified number in a gun or ammunition detachment or be detailed for some specified duty, which place he should occupy at all important drills in conjunction with other batteries, as also when actually engaging an enemy. Without losing his knowledge of other duties he should be perfect in every respect in his acquaintance with his own particular duty.

At all drills, except in the case of elementary gun drill, the shell and cartridge lifts should be invariably used, ammunition stores open, and ammunition, whether drill or not, brought up from the proper places. Wedge wads and gas checks brought up and used. Dummy fuzes of exact external appearance to the Service ones should be fixed. Range-takers and look-out parties should be all at their proper places. Those lamps should be all lit, which are required in the ammunition floor below by day. The drill as above should be carried out after dark as frequently as by daylight, when the fighting lanterns, &c., would be used. It is only by a weekly drill at least, of this nature being carried out, both by day and night, that we can hope to maintain the gunners, the batteries, and the works and their fittings and arrangements in a perfectly prepared condition, and capable of affording the maximum of resistance to an enemy.

In addition to the above drills, which are equivalent in a measure to

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the company or battalion drills of an infantry regiment, there should take place periodically in all fortified places, general drills of all the batteries in conjunction, corresponding to brigade drills of infantry, these drills would in fact be an almost exact rehearsal of what would take place in a siege. And here, let it be noted, that such rehearsals would have far more reality about them than the manœuvres of ordinary field days of the three Arms. For the fortress artilleryman knows beforehand the precise point from which the enemy's attack will come; and he alone, of all soldiers in the Service, drills beforehand on the exact ground where the encounter may at any time take place. Surely with such knowledge, given only well-trained men and thoroughly efficient *matériel*, the result should be assured.

Concerning then, what may be termed "fortress artillery tactics;" these can only be studied and perfected by frequently placing all the batteries (men and *matériel*) under one head; the men occupying those portions of the line of defence with which their previous training has made them perfectly familiar.

With a view to carrying out this idea, then, one of the first matters of importance would be to fix the position of the responsible head under whose directions the whole of the guns are to be fought; and also those of such officers under him, who are in charge of certain portions of the defence. These positions, unlike those of ordinary commanders in the field, would as a rule be unchanged; and consequently they can be prepared beforehand, (even in fortified places where all the latest modern appliances do not exist) with arrangements that would give to the commanders proper means of exercising complete control over their batteries. Protection from weather and shelter from an enemy's machine guns, or shrapnel fire can be provided in any fortress, when once the positions have been fixed upon.

The next matter of importance would be to place the fixed posts of commanders and all the batteries in communication with each other by the best means possible on the spot. Failing telegraphic or telephonic communication, very efficient transmission of orders, &c., may be maintained by a properly organised staff of well trained signallers under an experienced and responsible officer. These signallers should be provided by the infantry, who would usually be available in all large fortified places. The same men should be always employed until relieved as a whole by others, and they should be so constantly practised, as to be able at any time to take up their positions at once, and establish a chain of communication by day or night throughout the position.

If gunners are employed at this work they are taken away from their guns at a critical time; and, besides, they are less likely to prove efficient signallers than the infantry who have more time at their disposal for special work of the kind. A mere ability to read and transmit quickly the letters of the Morse alphabet by the methods in vogue by day or night is not sufficient to ensure reliable signalling, constant training and working together of the groups of signallers is absolutely indispensable.

In respect also to the employment of infantry, as an adjunct in other

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ways to artillery, there are certain duties even in the Service of the heaviest guns that can very well be performed by very slightly trained men; but it should be clearly determined beforehand what these duties are to be, and these, and these only, should infantry soldiers be taught.

These general drills then would have for their object the practising and perfecting of the system of defence, which has been prepared beforehand down to the most minute detail. It should be constantly practised either with or without actual gun practice at a towed target. But in either case small blank charges for each gun should be liberally allowed to be fired from those whose front is necessarily masked in peace time; and from all, when actual gun practice is not expedient. The cost of these rounds of blank would be small in comparison with the value accruing to the better training of the men, and to the perfecting of the system, the commander being able to detect at once many mistakes or delays in carrying out his orders, which would not otherwise be apparent.

It is to be understood that at these artillery field days, or defence rehearsals, the officer in charge of the whole line of defence should, from his well-chosen commanding position, be able to determine generally which guns should be employed for a specific purpose, and also to designate the object in view. The details of obtaining the result required in the most efficacious manner being left to those in charge of certain portions of the defence. Thus, for example, the commander might be supposed to communicate to the officer in charge of the eastern portion of the defence;—"engage enemy's ship (*A*) at anchor with as many guns as possible with Palliser shot till further orders;" to the officer in charge of western portion "fire six rounds of heavy shrapnel, 10-inch or over, against the deck and tops of enemy's ship (*B*) steaming to the west," or "fire four rounds of heavy case shot against enemy's torpedo launch (*C*) steaming in shore."

The officers in charge of the different portions of the defence should have no difficulty in carrying out such orders, provided the system under which they work their portions of the defence had been frequently rehearsed. The degree of efficiency of the result produced would of course depend, besides, upon the means at disposal.

With modern guns, position finders, telephonic or telegraphic communication between batteries, and use of electric light, &c., results could be obtained quite incomparable with what one might expect, from the armament and appliances usually to be met with in fortresses unfortunately. But unless a proper scheme of defence has been thoroughly worked out in all its details, commencing with the training of the recruit gunner and working upwards, and unless such a system has been thoroughly perfected by frequent practising, it is useless to expect that a modern armament and its necessary scientific concomitants, will produce a much better result than would be obtained from a defence relying entirely on obsolete weapons and means. Nay, more, it is assuredly the case, that every day it becomes additionally necessary, unless bitter failure is to happen in critical times, that,

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"fortress artillery tactics" as we may term them, should become a study.

In conclusion, it has been acknowledged by all who have any knowledge whatever of the subject, that the service of fortress artillery can only be learnt by long practice and experience, and that it is a branch of the service requiring above all things a special training for its officers and men. Let it then be so considered, and let not officers and men be blamed because their training and instruction sometimes fall short of real excellence. Let, however, the fortress artilleryman always bear in mind that even with inferior tools good work may be turned out, and that superiority of tools will never make up for lack of knowledge on the part of the workman.

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THE EXPEDITION TO THE RUBY MINES OF UPPER BURMA.

(A SHORT SKETCH.)

BY

CAPTAIN W. N. LLOYD, R.A.

Of the many expeditions, marches, countermarches and actions that have taken place during this arduous campaign, it is impossible to point to one in particular as being the most important from either a military or civil point of view, but I can assert with confidence, that both in this country and in England the expedition to the Ruby Mines has attracted the most attention, possibly from the fact of the name being attractive, and that the expedition was important is also certain. When it was known at Mandalay that an expedition was to start for the mines, officers clamoured to be employed, as it was known that there would be much interest attached to it, that the Shans would certainly fight, and then again there were bags of rubies looming in the distance! Being among those fortunate ones, I was ordered to leave Mandalay on 10th December, with my Subaltern, Lieut. Parker, R.A., and the Gardner Machine Guns (which I had just organized and equipped for service) and to join the main body of the Ruby Mine Column at Sagadoung.

The base of supplies of the expedition was a place called Khyannyat on the Irrawaddy, about 80 miles north of Mandalay. A force had been despatched to this place in November to open out the road leading to the mines; great difficulties had been experienced both from the ravages of fever, dysentry and cholera, and also during the road making; at the date on which we started for Khyannyat this force had cut its way as far as Sagadoung, some 38 miles from Khyannyat at the base of the mountains. The country between these two villages was covered with dense jungle, and perfectly flat; even during this, the cold season, the climate was exceedingly unhealthy, and during the rains it would be, I should say, simply deadly. Naturally then the advance of this force had been slow, the jungle had to be cleared step by step, while sickness thinned the ranks; they had been twice attacked by the Shans, but had driven them back with loss, and were now established at Sagadoung.

Leaving Mandalay with my guns on 10th December, in the same

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steamer with Sir F. Roberts (who was proceeding on a tour of inspection) we reached Khyannyat on 13th; here we disembarked, and on the 15th set out for Sagadoung under escort of 100 men of the South Yorkshire Regiment. We met with no opposition from the enemy, and reached the main body on the 17th. We found that the 43rd Goorkha and South Yorkshire Regiment had been considerably reduced in numbers by sickness, while of the 300 Bengal Sappers and Miners originally sent out in November, only 120 men remained fit for duty.

Active preparations were now made for an immediate advance up the mountains, and on the 19th, taking 10 days' rations with us, we commenced the ascent with the following force:—

350 men of 43rd Goorkha Regiment under Col. Cubitt, F.C.
150 " South Yorkshire Regiment under Capt. Earle,
100 Bengal Sappers and Miners under Lieut. Petree, R.A.,
2 mountain guns and 2 machine guns under Capt. Lloyd, R.A.,

together with the hospital and transport, consisting of about 700 mules.

The whole force was under the command of Brig.-Gen. Stewart, A.-D.-C., with Major Neville Chamberlain as D.-A.-A.-G., and Capt. Hume, A.-D.-C. as Intelligence Officer.

Mr. Streeter and Major Bill, representing the firm of Messrs. Streeter & Co., also accompanied the column.

Our road at first lay in a south-east direction, and was really nothing more than a goat track, very rocky and precipitous, through thick jungle, with many obstacles, both natural and artificial, strewn in our way. Halts had to be called continually; sometimes, perhaps, the sappers had to remove a huge tree, sometimes to administer a dose of dynamite to an obnoxious rock! We struggled on, however, anticipating a fight with the enemy, and feeling that at every step the fever stricken plains were being left further behind us. On the first day we covered seven miles in eight hours, having advanced to a village supposed to be Luikor. We pushed on again on the following morning, the road became worse, and the unfortunate mules, although lightly loaded, experienced great difficulty in overcoming obstacles; so much so that at 4 o'clock, when the column reached the camping ground the baggage animals were still struggling on some way in rear—we had only covered three miles of ground! Night came on and overtook the poor mules before their day's task was completed; the darkness on the jungle path was intense; the mule drivers became terrified, the animals, not being able to see a yard in front of them, fell over rocks, into holes, and some down the khud,—confusion reigned supreme. In this country one mule driver is detailed to three mules, he leads No. 1, while 2 and 3 are hooked on in rear by chains, so that they must perforce follow No. 1, or have their necks dislocated. So, in many cases, if No. 1 fell, 2 and 3 came down with him, and in this manner the road became completely blocked; mules bellowed, drivers yelled, Europeans gave orders, and thus was night made hideous.

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However, remembering our old friend Horace's maxim "*Aequam memento rebus in arduis, servare mentem,*" those not engaged in extricating mules acted accordingly, by lighting a huge bonfire and singing popular airs of the day, until the arrival of tents and blankets. By the aid of torches, lanterns, and a quantity of bad language, the last mule was brought into camp about midnight, but the baggage had been mixed up to such a degree that it was hard to find one's belongings. We halted at this camp on the following day, as we had to construct a stockade, and we were thus enabled to pull ourselves together and recover lost baggage. At daybreak on 22nd, we moved forward again, having taken in another 10 days' rations per corps. The road was still most difficult, we reached the village of Nampote at about 11 a.m., and found it deserted, the entrance having been barricaded, and a stockade constructed which overlooked the road. While halted here the Shan scouts let us know, for the first time, of their presence, by firing four or five shots at us from the jungle above. Having parked the baggage in the village under an escort, a reconnaissance in force was at once pushed forward, which found, at about two miles from Nampote, a strong stockade, constructed among the rocks in thick jungle, recently evacuated; the enemy's fires were still burning in it. The Infantry were sent further forward and came across a small body of about 40 Shans quietly retreating; these having been scattered by a few volleys, the Infantry retired, and the stockade having been destroyed, the reconnaissance returned to the village and encamped for the night.

On the following day we advanced again, but with caution, as we fully expected to encounter the enemy. Not far from the spot where we had seen the Shans on the previous day, our road wound down through long grass into a rice-growing valley, watered by the Myin river; here we made prisoners of seven villagers belonging to a trading tribe called Li Shaws, who gave us valuable information regarding the dispositions of the dacoits hired by the lessees and merchants of the ruby mining districts to oppose our advance. We halted at Pyaungaung, having done a six-mile march in eight hours! We pitched our camp in some damp rice fields—and precious cold it was; we were now at a height of 6,200 feet, the thermometer at 7 o'clock next morning registering 6° of frost. Some shots were fired into camp during the afternoon from the neighbouring jungle, but the offenders were quickly turned out by a few Goorkhas.

Next morning, the 24th Dec., the wretched natives of our force were so benumbed with the cold, that tents could not be struck or baggage packed until they had thawed sufficiently, so a forward movement was not made until 9 a.m.

From information received we expected to come in contact with the enemy, so we marched in fighting formation, and had covered some three or four miles, when the enemy were reported in stockades to our front. At this place, called Ingand, the road forked, one path leading to our right front over a high pass to Kyatpyen, and the other to our left front over the Toan-me-Daik Pass towards Mogôk. The Shans had stockaded themselves at the top of the former and at the foot of the

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latter pass, both stockades being concealed from view in the dense forest jungle. The enemy's positions were indicated only by a thin line of smoke which rose through the jungle. These fires had been foolishly lit as signals, and little were they aware of the assistance thus given to us.

It appears that they intended to take our force in rear by whichever road we might march—if we selected to attack the right stockade, then the Shans from the left would swoop down on our rear, and *vice versâ*. General Stewart determined to attack the right, as our road lay to the left, and accordingly ordered Lieut.-Col. Skene with some 150 Goorkhas and South Yorkshire Regiment to turn the enemy out. A capital position was found for the Mountain Guns and the Gardners on a knoll in the valley, from which not only the Passes could be shelled, but also the road between the enemy's two positions completely swept, thus effectually protecting Col. Skene's left flank. The Infantry advance was carried out under fire from the guns, which made some pretty practice, dropping several shells at 1600 yards range into the smoke which indicated the enemy's position. One of these shells was fortunate enough to dispose of three Shans and to wound seven others. While thus engaged the Shans from the left made a feeble attempt to carry out their tactics by coming to the edge of the jungle in rear of Col. Skene's advance and amused themselves by opening fire on the guns. We turned the machine guns on to them, and were not afterwards bothered. The guns now "ceased firing" as our attacking force was nearing the stockade. A long and anxious time elapsed before the first shot was fired from the jungle. The fight commenced with dropping shots, developing at last into a roar of musketry, amid which could be distinguished the crack of the rifle, the boom of the jingal, and the roar of the old Brown Bess. After about ten minutes there was a lull, followed by a few rapid volleys, and a ringing British cheer which told us that the stockade was ours. Only two of the South Yorkshire Regiment were wounded, one very severely, poor fellow, his leg being shattered above the knee by a charge of slugs at close quarters. The density of the forest saved many a life, as an inspection of the trees will prove. It was too late in the day to attack the left stockade when Col. Skene's force returned, so camp was pitched for the night at Ingank. Dec. 25th broke on real Christmas weather, it was bitterly cold, hoar-frost lying on the ground, while ice was cut out of many a warrior's basin. The General determined to halt for the day, as a convoy of provisions was expected, and a post, in the shape of a stockade, had to be constructed.

After a Christmas sermon from Padré Adams, V.C., we all set to work to prepare for as merry an evening as possible: although Officers were only allowed one mule each to carry their tent, chair, and their baggage, I nevertheless noticed one ingenious and provident "Sub" who produced a plum pudding from a kerosine oil tin, and another, an old campaigner, no less a luxury than two bottles of Perrier Jouet '74! "It is a poor heart that never rejoices," and notwithstanding the surroundings, we spent a really merry evening, which ended in a "sing-song," and then toddled off to our blankets ready for an early start, and the Shans, next day.

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We advanced on the following morning, orders having been issued to the effect that the baggage was to remain in camp under a guard until the column should have cleared the gorge. Our advance was conducted with the greatest caution, as this is a war of ambuscades, and to knock one's head against a stockade is a matter of the greatest facility, for they are generally arranged in such a manner as to be completely hidden by jungle, and invisible at 50 yards distance. I must mention that General Stewart had sent out a reconnoitring party on Christmas Day, who reported that, to the best of their belief, the large stockade was deserted, and this intelligence unfortunately proved to be true. I say unfortunately, because we had been looking forward to giving the Shans a good lesson, and were therefore disappointed; as a matter of fact, the evacuation of the stockade removed many difficulties. The road to the mines was now open to us, and we had no more wounded to attend to, or dead to mourn; for most assuredly many would have lost their lives had the enemy held their position—it was immensely strong, in fact almost impregnable in European hands; every means for slaughtering us having been devised, even to huge rocks being ready to roll on our heads. The approach to the stockade was steep, *abatis* of every description was strewn in our path, strong flanking stockades had been constructed so as to bring our advancing troops under a heavy fire while endeavouring to overcome obstacles. As it turned out we should have completely routed the Shans had they clung to the position, as a force of 150 Goorkhas, which had been despatched to turn the position, arrived in rear of the stockade within two minutes of our arrival in front, which was a most creditable and well-timed movement, whereby a severe lesson would have been administered. Having destroyed the stockades, we crossed the Toan-me-Daik Pass, and descended by a most precipitous and rocky track towards the Ruby Mine Valley, halting for the night at an open spot some two miles from Mogôk. The last two or three miles of the road had been cut up by water channels, dug for mining operations, making the already miserable path almost impassable for baggage animals. Consequently, our animals were once more on the march when darkness overtook them, and they suffered considerably, poor beasts. The mule is truly a wonderful animal, as this campaign has demonstrated. I have seen a mule fall down the khud, some 20 or 30 feet, with his load on, he will hit rocks and trees with great force *en route*, and you inwardly ejaculate—"Well, he's a stiff'n,"—but no! Take off the load, pull him up, and he will shake himself, and appear as jolly as a sand boy. On this particular night the transport officer was out on the road until 3 a.m., digging animals out of holes and bringing in stragglers.

We moved off again at daybreak next morning advancing slowly and cautiously, as an attack or ambuscade was by no means improbable; having marched about two miles without opposition, we at length arrived at a low ridge of hills overlooking the town of Mogôk.

Here a sight, long to be remembered, presented itself, a long narrow valley, shut in on all sides by fine jungle-clad hills, a mountain stream wending its way down the centre of it, while under the hills,

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picturesquely set off by scattered groups of tapering pagodas and carved kyoungs, nestled the two prosperous villages known as Mogôk; in the distance, on different roads, were the inhabitants moving off with all their goods and chattels, and here and there men hurrying from their houses carrying off the last of their property. The two villages, which contained some 600 houses and 300 pagodas, appeared to be deserted, and not a head of cattle was to be seen. While we were taking in this remarkable and picturesque scene,—which strongly reminded me of a picture described by Ryder Haggard in "King Solomon's Mines,"—we observed two or three men advancing from the opposite village bearing a flag of truce; the General interviewed them and found that they wished to submit unconditionally. They, of course, had taken no part in opposing us, they were peaceful villagers, so they said, and the dacoits had looted them! The General taking these assurances "*cum grano salis*," informed them that if they disarmed and returned to their homes, their lives and property would be respected. We happened to know for certain that some five or six hundred of these very villagers were the garrison of the large stockade which we had found deserted; it was our policy, however, for the present to ignore this fact.

Five or six days elapsed before the Shans, having gained a certain amount of confidence, returned with their wives and families to their homes. At the time I now write, Mogôk has assumed its normal aspect, all is peaceful and tranquil, the cattle can be seen feeding on the rice fields, business is brisk, mines are being worked, and a large fair is held every five days in the market place, where our little Goorkhas may be seen making love to the Shan ladies! We are now able to buy cattle and fat pigs, whose size and condition would compare favorably with the best prize "Berkshire;" vegetables are plentiful and in variety, consisting of tomatoes, beans, yams, cabbage, melons and pumpkins, while pear, peach, plum and apple trees flourish in the small gardens which surround the houses. Having secured ourselves at Mogôk, columns were despatched to the chief villages in the district to establish the British rule. The old village of Kalké was occupied without opposition, but at Mainloung our force found the dacoits, under the celebrated Kunsine, strongly stockaded. The Goorkhas and South Yorkshire Regiment soon settled matters by charging home and driving them out at the point of the bayonet, killing six, wounding several, taking thirteen prisoners and some cattle. Kunsine escaped, leaving his fur coat behind him (which afterwards adorned the manly form of our Intelligence Officer); he, however, subsequently submitted, and having been reinstated on the Mainloung throne by our political officer, is now, curiously enough, our sworn ally.

A column was also depatched to Tebetkyen (on the river) *viâ* Kalké, to come to terms with another celebrated dacoit, Po-kwa, who submitted at once. This Kalké-Tebetkyen route will in future be utilized as the line of communications to the Ruby Mines from the river, as we discovered that it is some 25 miles shorter than the Sagadoung-Khyannyat route, which will be abolished. In this manner, the

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surrounding district, within a radius of 25 miles of Mogôk, has been gradually subdued, and at the time I write, is to the best of our belief, peaceful and free from strife and brigandage.

As regards the Ruby Mines themselves, they have not as yet passed into the hands of Mr. Streeter, but terms will soon be agreed upon between that gentleman and the government. Meanwhile the Shans can work the mines by obtaining a licence from our political officer, who imposes a tax of 25 per cent. on all stones sold.

The Ruby mines are of four kinds: the most valuable and productive being gullies formed by the action of the water on the sides of the hills; next to these come the mines formed by shafts sunk into the hill side, and lastly, wells which are sunk in the valley, and are of two descriptions, namely, the deep (20 feet) and the shallow (4 feet), where the first ruby-bearing stratum is found. Few, if any, good rubies have been shown to us since our arrival; stones of value are, I fancy, sent direct to the Mandalay market; but rubies and stones *of sorts* are offered for sale *ad infinitum*, and you will scarcely believe it, that here, at the very mines themselves, glass is palmed off on the unwary! I hear on the best authority, that our Post Office officials opened a large packet addressed to the Ruby Mines, expecting to find percussion caps, but to their astonishment the contents proved to be rubies from Birmingham! It is stated that a Shan merchant having disposed of £5000 worth of rubies in England, at once invested £2000 in glass. Only last week two beautiful looking rubies (?) were handed to me for sale, but with Mr. Streeter's assistance I was not only able to pronounce them as glass, but at the same time invested the wily Shan, who presented them, with the Imperial order of "the boot!" The inhabitants of the mines are well-to-do and extremely independent; the actual miners are either Shans in their enormous broad-brimmed straw hats and baggy trousers, or Chinamen in indigo blue; but of late a new miner, keen and determined, has made his appearance; it is noticed that he works with great zeal but with small results, this miner may be observed from "sunny morn till dewy eve" over the mouth of a pit, his head and shoulders hidden, while a back view presents to the eye a huge hob-nailed boot with enormous breadth of beam—it is no other than our old friend Tommy Atkins! However small his success at ruby mining may be, he has, during this campaign, done right good work in his proper sphere, and I hope the time has now arrived when his services will no longer be required, but that the country, which we have taken over with such difficulty and loss of life, may hereafter be peaceful and prosperous, and prove itself to be a valuable acquisition to the British Crown.

Mogôk Ruby Mines,
March 5th, 1887.

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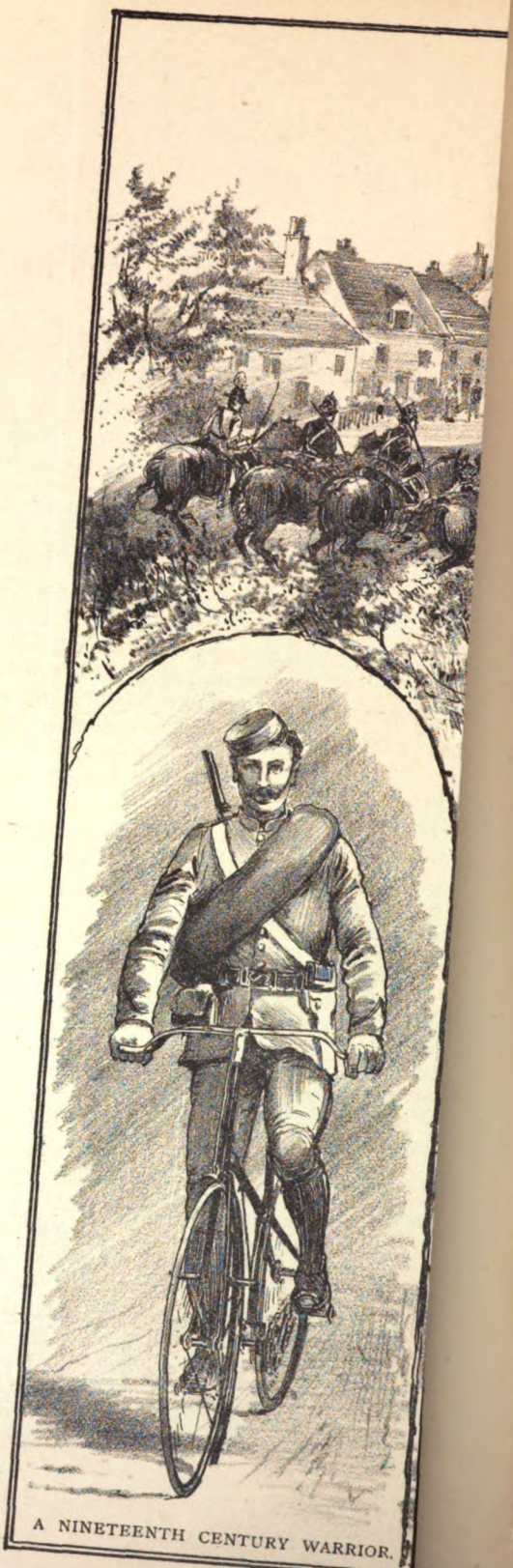

A NINETEENTH CENTURY WARRIOR.

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CYCLISTS AT VOLUNTEER MANŒUVRES.

BY

LT.-COL. E. KENSINGTON, R.A.

A Lecture delivered at the Royal Artillery Institution, Woolwich, Monday, 2nd May, 1887.

(COLONEL M. LE FER TAYLOR, R.A., IN THE CHAIR.)

LIEUT.-COL. KENSINGTON.—Colonel Taylor, Ladies and Gentlemen; I venture to hope that you may be interested in our cyclist adventures at Dover, in consequence of the question of army cycling having been taken up by other nations. We find that the Italians adopted bicycling in some of their manœuvres so long as 12 years ago. Lately, I understand, Gen. Boulanger has had his attention directed to the question, and in Germany some use of bicycles has been made for orderly work between fortresses and towns when some distance apart. Instructions have also been given in Germany to Commanding Officers to make use of cycles (bicycles and tricycles) wherever the telegraph might fail.

Colonel Stracey, Commanding Scots Fusilier Guards, was placed in command of the Corp of Volunteers marching from Canterbury to Dover. Finding himself short of cavalry, the idea struck him that he might use cyclists in their stead, so he communicated with Lieut.-Col. Savile, *late* Royal Irish Regiment, Professor of Tactics at the R. M. College, who has taken the lead to a great extent in cycling in this country, being the head of the Cyclist Touring Club, numbering nearly 25,000 members. Colonel Savile was fortunate in obtaining the assistance of Mr. Fox of the 3rd Battalion, Middlesex Regiment, as his Adjutant. They were both indefatigable. There was only about a week for all arrangements to be made. Colonel Stracey called a meeting at the Horse Guards and explained his views; also printed instructions were issued to all those whose names were accepted, and arrangements made for assembling them in Canterbury. Each man was to arrive equipped with all that he might require, haversack with provisions for the day, water bottle filled, map and waterproof cape. There was not much said about arms, but Colonel Stracey expressed a wish that everyone should, if possible, be armed with, at least, a revolver. Particular attention was called to all points relating to the good condition of the machines, the examination of nuts and tires, the filling of oil cans. All cyclists on reaching Canterbury were to report themselves at the "Falstaff Hotel," which was named as the

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head-quarters of the corps, and not to break off, but to wait with their machines until they were inspected. Each man was cautioned that the success of the whole undertaking rested upon all individuals, bearing in mind that they came, not merely for pleasure, but to promote the interests of cycling and the success of the army operations in which they were intended to assist. They were told to be very careful to obey all orders and instructions as regards conduct and discipline in every way. Arrangements were also made that those who intended to ride down should meet at Trafalgar Square, where a sergeant was to be in attendance to escort them; while those going by train were to report at Victoria Station to Mr. Fox, who had secured special carriages for the cyclists and their machines. The ride from Trafalgar Square did not come off, owing to the strength of an easterly gale. About 70 cyclists reported, the great majority being civilians. The first parade was ordered for noon on Good Friday, at St. Thomas's College, about a mile out of Canterbury, at the top of the hill on the Whitstable Road. The preceding evening Colonel Savile explained to the officers the general idea and his particular plans.

Colonel Stracey's orders were that the force should march on Saturday from Canterbury to Dover in three parallel columns, and should be guarded on the flanks first by infantry scouts, secondly by cyclists. Colonel Savile devised a plan for the preceding day, Good Friday, in order to train the cyclists, so that they might not be found entirely ignorant of what was expected from them on the Saturday. This plan was not in any way connected with Colonel Stracey's idea, but belonged to a different campaign. The cyclists were to operate on the part of invaders who were supposed to have landed near Sandwich, and to have pushed forward a corps of cyclists to examine the country, and to ascertain mainly whether Whitstable was occupied by the defenders, also if the country was clear between Whitstable and Faversham and Challock Lees, and to report whether Faversham were capable of being converted into a defensible position. The invaders had their attention directed to Whitstable by noticing the line of railway leading from Canterbury to Whitstable, so that, for all they knew, there might be a naval station there. It was necessary for them to ascertain if there were any ships of war with sailors or marines who could attack them on the flank if they moved on to Faversham.

We will now turn our attention to the cyclists wending their way, some walking, some riding up the hill leading to St. Thomas's College. On arriving the whole corps was photographed, and then told off into two divisions, right and left. The right division was placed under my command, and the left under that of Major Carpenter, of the Army Reserve, who is now engaged in raising a corps of "Cyclists Guides." The two divisions were to detach their tricycles to accompany Colonel Savile, who was about to move along the main road to Faversham. The bicyclists were to scout under their respective commanders.

I must remind you that these cyclists had for the most part no knowledge of the most ordinary elements of drill, so that before starting we had to put the men through a certain amount of elementary drill without their machines; we next arranged them with their

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machines in four companies, and showed how, if they were beset by cavalry, they might construct zarebas, by the ordinary method of forming square. The cyclists showed their intelligence by taking up the idea at once—one or two attempts and they were perfect at it. I think it may be said generally that a cyclist who is devoted to his sport, and who uses it for touring, is necessarily intelligent. If he were not intelligent, he would not care to be going about the country, and would not find his way if he tried. The little experience I have had of these cyclists at Dover is that they are men of great intelligence, and I think that is a point to be borne in mind when we propose to utilize them for military purposes. After drill we broke off for lunch, whilst the officers of the corps were very kindly entertained by the Principal of St. Thomas's College. Then we made a final start at 2.30.

I will first tell you what was done on the right. We moved at a rapid pace, with an advanced-guard of two scouts, along the Whitstable road against a strong north-easterly wind. On reaching Honey Hill, I detached Capt. de Lara Cohen, of the Tower Hamlets Engineers with 6 of my force of 20, to make their way to a place called Nagden Ferry, giving him orders to detach a couple of men to go *viâ* Herne Hill to Boughton Street, there to communicate with the tricycles under Colonel Savile, who was occupied with searching the woody district along the Faversham Road, and who needed to be informed whether the country was clear on the northern slopes of Boughton Hill, before proceeding to Faversham. I wish to show that the cyclists were here used for the purpose of keeping up communications between diverging columns, this being of the purposes for which cyclists will be found eminently useful.

With the rest of my party I continued till we arrived in sight of Whitstable, then I posted the main body under Sergt. Gentry of the East Kent Volunteers, whose local knowledge I found invaluable on both days, and went with three men on bicycles to examine Whitstable. We were always careful about going in proper order so that when the main body was moved we had at least two scouts in front who had instructions to stop on the top of the hills. They had to ascertain from the top that all was clear in front, and then to receive their orders from me again before starting. This was very necessary, otherwise I should have found my column running away from me; besides, I purposed giving instruction, and making it understood that, when moving in an enemy's country, one must protect the main body by careful scouting. So, although I do not always mention it, I shall be glad if you will understand that we always adopted this system of having scouts in front, with certain instructions to prevent their getting out of hand. There was a bugler with each division, but the one with me was unable to keep up. In penetrating Whitstable I allowed an interval of about 100 yards between each, and gave orders that anyone seeing signs of the enemy, particularly blue jackets, was to retrace his steps as fast as he possibly could, to bring back the information. We found the town clear. I was to have sent a telegram to Faversham to inform Colonel Savile, but, it being Good Friday, the office

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was closed. I then rejoined the rest of the party, and we continued along the road *viâ* Seasalter and Graveney. We now had a good wind behind us, but a bad road for half-a-mile, scarcely better than a pebble beach with cart tracks. We being all mounted on bicycles were able to keep our seats, but tricycles, unless of a two-track type, would have been in difficulties, I do not think they could have been ridden. At Graveney, where the road crosses the railway, we ascertained that Captain Cohen's party had passed about ten minutes before. It was easy riding into Faversham. Colonel Savile had arrived. He had received the information sent by me from Honey Hill. Before long Captain Cohen came in and gave an account of what he had done in compliance with his instructions, which were these,—to find out at Nagden Ferry if the river was fordable, if the position was defensible, and further to make his way across country, over a creek that runs into the main creek, and so into Faversham, thus saving a ride round of about nine miles. This he succeeded in doing. I should mention that Captain Cohen, not having ridden a machine this season, was on horseback. He reported that he could not have got round had it not been for the help of his cyclists. Thus the opinion was borne out that a bicyclist can find his way anywhere; wherever he can get himself he can, in general, take his machine. Perhaps a broad deep ditch might be an exception. Any hedge that he can get through, or any wall that he can climb he can take his machine over also. For example, on Easter Monday evening at the South Eastern Station, Dover, there was such a crush that I had to carry my bicycle over my head.

To return to Friday's operations, the bicycles of the left division pursued the road from Canterbury to Challock Lees, detaching parties to the right from Chilham and other places, *en route*. They experienced bad roads and heavy winds, but arrived at Faversham little later than was expected. In the meantime the country in advance of Faversham had been reconnoitred. In particular, one of the cyclists who was sent to examine a hill near the village of Ospringe, brought back a survey sketch of the ground: it turned out that he was a surveyor by profession, and had turned his knowledge to account. On returning I was sent with the bicycles of my division as an advance guard. Taking advantage of a hill just before reaching Canterbury I showed them how to form up to the reverse flank. They caught the idea at once and put it in practice on coming into Canterbury, forming in front of the Hotel at the side of the road, so as not to interfere with the traffic. Nothing could have been better than the way in which each, as he came up, jumped from his machine and ran it up into place. Before dismissal, orders were issued for parade at the Falstaff at 8.30 the next morning. Also a smoking concert was announced for that evening. This could not commence till 10 o'clock, as work was going on in the only available room—Colonel Savile was giving his instructions for the employment of our cyclists on the morrow.

The general idea was that we were to relieve Dover from a besieging enemy, who had disembarked at Sandwich.

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The three columns were to march by the following routes:—centre column from Bridge along the main Dover road; right column from Nackington by way of Lower Hardres, Upper Hardres, Bladbean and Selsted; the left from Bekesbourne, nearly following the line of railway by Adisham, Holt Street and Eythorne. They were to halt at Bladbean, Broom Park, and Holt Street between the hours of twelve and one, during which time all operations were to cease. On both flanks were to be infantry scouts, who were volunteers called for by Colonel Stracey, capable of marching their 30 miles a day with their arms and provisions; they were to serve as a connection between the marching columns and the cyclists who were to scout in front and outside. In case of meeting with the enemy there were certain towns, Petham, Elham, and Alkham on the right; Goodnestone, Chillenden, and Tilmanstone on the left, which were appointed as rallying posts. If the enemy were encountered, the cyclists would fall back on the infantry scouts, and with them make for the nearest rallying post, whence messages for succour could be sent to the main body. My own instructions for the right were to examine the country bounded by the main road to Ashford, and from there to Folkestone, Alkham and Ewell, where I was to report; Ewell being near Kearsney, two or three miles north of Dover. I was to send off a pigeon from Ashford. Colonel Savile personally superintended the operations on the left. Both cyclist divisions were to leave headquarters at 8.30 for their respective rendezvous at Street End on the right and Littlebourne on the left.

Saturday morning broke with the finest weather, but the same strong easterly wind. We rode at a rapid pace up the hill past Nackington, and then down to Street End, leaving a scout at any doubtful turning to await Captain Cohen who, being on horseback, could not keep up with us. We mustered only about two-thirds of the men we had the day before, but these were all good and reliable. The infantry scouts met about half-a-mile further to the west, at the crossing of Stone Street, an old Roman road which runs nearly due south from Canterbury towards Hythe. I detached Captain Cohen and the main body of cyclists with written orders to proceed to Petham, and there to send off parties, then to follow the valley, and turn off at North Leigh, across the Roman road to Stelling Minnis, whence he would find a fairly good road leading by Sibton Park to Lyminge. This village he was to approach with special caution and, if safe, to occupy from 12 to 1—Lyminge being rather in advance of the front of the marching columns at that time. He was to examine the side roads as far as he was able with the limited numbers at his command; if pressed by cavalry he was to fall back on the infantry scouts, or down the valley of the Little Stour to the rallying point at Elham. He was further to use his best endeavours to meet me at Folkestone railway station at 2.30, after which he was to move on to Alkham and Ewell. The other parties detached at Petham received their written orders from Captain Cohen. Two were to proceed to Hastingleigh and on to Wye down a very steep hill—Hastingleigh being the highest point in the whole neighbourhood, and therefore appropriate for a look-

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out. At Wye they were to send off a telegram to Colonel Stracey at Adisham Station, and then to join me at Ashford, at the South-Eastern Railway Station. Another party of two men were to go from Petham to Waltham, and by a different route to Hastingleigh, then by Brabourne and Smeeth to the crossing of the main road from Ashford to Hythe. There they were to wait till one o'clock. I have already mentioned that my force on this day was very small, this prevented my doing as much as I wished in keeping up lateral communications. The ride to Whitstable against the wind, and then a good pace from Faversham to Canterbury—also more or less against the wind—told upon men who had come straight from their desks, so that they were not able to turn up the next morning. Possibly also a smoking concert, which was kept up till one o'clock the night before, may have had some effect. But I am glad to be able to say that of all those who came to the rendezvous, not one failed in any single duty which was assigned to him. (Cheers). After sending off Capt. Cohen from Street End, I rode with but one orderly over Chartham Downs to Schalmsford Street, where I came into the main Canterbury and Ashford road, which I followed at full speed, passing Godmersham and Kennington. We did the 15 miles to Ashford in an hour and twenty minutes. There I sent off the pigeon to the Commanding Officer at Dover, and awaited the two men coming round by Wye. They were later than I expected, in consequence of very rough hilly roads; one of them had had a fall owing to the roughness and ruts when mounting, he bent his handles somewhat, but was not disabled. I sent off a telegram and started for Smeeth, which we just reached by 1 o'clock. There I found my scouts from Hastingleigh and Brabourne. They had made all enquiries, and watched the high road for a couple of hours, but had seen no sign of the enemy.

From Smeeth we went on to Sellinge; there I despatched another telegram to Adisham Station. After leaving Sellinge, the wind became stronger; I never wish to have a harder struggle than that ride through Hythe and Sandgate to Folkestone, which however we reached at 2.40 p.m., only 10 minutes after the time appointed for the rendezvous with Captain Cohen; he had been there about a quarter-of-an-hour, and was just about to start. Thus I had my whole force assembled at Folkestone. The orders given me were not to proceed by the Dover road, but to go round by the Alkham valley leading to Ewell. I sent on Captain Cohen with his force as an advanced guard, and followed in a quarter-of-an-hour with the remainder. When half way to Alkham, the scouts turned back with the announcement that cavalry were in front. Our party retreated a mile or two and took refuge up a lane, from which it could be seen that they were a troop of yeomanry returning from the manœuvres. We were bound to regard all Cavalry as hostile, and to manœuvre so as to conceal ourselves from them. We knew Colonel Stracey had no cavalry, but we did not know till afterwards that Colonel Brackenbury, C.B., commanding in Dover, and with whom we were co-operating, had a force of yeomanry. Captain Cohen's party had now rejoined me. Our scouts again sighted cavalry. This happened three times whilst riding at a good pace, and every

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time they jumped off their machines and turned back without having been noticed. I have not heard that any of these parties of cavalry ever saw one single cyclist of our division. (Applause.)

As soon as the scouts were seen coming back the rest of the party reversed their machines. I waited to receive the report, and after a short retreat took shelter in a farm yard, abutting on the road we were pursuing. We hid the machines in the straw, and I posted my men behind the walls of the farm yard and the corners of the buildings, so that we were ready to open fire upon the enemy if we thought we were strong enough to take the offensive; when they came by they proved to be a half battery of artillery. I have no doubt that, although they outnumbered us in the proportion of 2 or 3 to 1, yet, as we were taking them by surprise, with our revolvers at a range of about 5 yards (laughter) we should have captured the battery—we could certainly have disabled them. However that was not what we were intended to do, we were scouting, it was our duty to remain unseen, and we were unseen. The next party we came across was too large a force of yeomanry cavalry for us to have mastered. Again we retraced our steps until we came across a convenient hiding place, which happened to be another farm yard, and we concealed ourselves and our machines as before, all knowing now what to do. We encountered no more cavalry, but on reaching Alkham, I saw a party of our infantry scouts approaching from another direction. I awaited them and ascertained that the cavalry had been scouring the country in search of us, with orders to take up all cyclists that they might come across. The reason is very clear why they never caught us: because, as I learnt from their Commanding Officer next day, the cavalry only searched up to about the inner limit of the country scouted by us. They were not able to ride their horses over distances easily covered by cyclists. Within that limit cyclists were unnecessary, as the work was done by infantry; this marks the advantages of the cyclist. We came in good order from Alkham to Ewell, where I had just drawn up my party by the side of the road, when Colonel Stracey arrived. He inspected us, and on receipt of my report, was good enough to express his thorough approbation. We rode into Dover, and I dismissed my party after giving them orders for the next day. I cannot say much for our personal experience at this time, we were covered with dust, and, in some cases, with pipe-clay. Pipe-clay gloves are about the very worst things that a cyclist could wear; he gets very hot, and his gloves are soaked; he has to take papers out of his pocket, and write despatches, also to pull out money to pay for telegrams; the result may be imagined. Dark clothes do not look so well, when covered with dust, as grey. There were two or three men in grey cloth, who finished as spick and span as when they started; notably members of the Artists Corps, in grey uniform, with their cloaks neatly folded round their shoulders, who always looked well wherever I saw them, whatever their work might be. Grey is, in my opinion, the colour that ought to be adopted for anything in the nature of cycling. (Applause). We were most of us tired, I can speak for myself, all however were most cheerful and persevering, I have seldom come across a pleasanter

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set of fellows to work with than they were in every respect. I had been warned beforehand to be careful that some of these long distance riders did not ride away from me. I was told that they would be wanting to do their 200 miles, I found nothing of this kind. On the Friday, certainly, at the end of our day's work, some of them went off to have a good ride, but as long as they were with me there was never an instance of a man wanting to do more or less than his duty required. But if any special work was to be volunteered for, they were always ready. This concludes the account of the right division of cyclists.

The left division were to start from Littlebourne on the Little Stour River. One party was sent across Grove ferry over the Great Stour, to go by Sarre towards Ramsgate, turning soon after Minster along the road to Sandwich. They were to stop south of the town, and to await instructions. Another party turned off at Wingham, through Ash, and on to the village of Eastry, situated on a main road running straight from Sandwich to Dover, by way of Whitfield. The main body, under Colonel Savile, turned off at Brandling and made for Staple and Eastry. Major Carpenter took the line of the rallying points, Goodnestone, Chillenden and Tilmanstone; Tilmanstone, Eastry and Sandwich were the limits to be reached at the resting time, 12 to 1. On communicating with the party at Sandwich, Colonel Savile ordered them to proceed by the coast road to Dover, but they mistook the way, and joined him later in the day on the Whitfield road.

On reaching the village of Eastry about 12 o'clock, Colonel Savile halted his party for the hour. During that hour six cavalrymen rode up, and claimed to make the 17 cyclists prisoners. The cyclists pointed out that there was a truce between 12 and 1—all operations were to have ceased; also that they were more numerous than the cavalry. The cavalry eager for their prey, insisted that each of themselves was supposed to count as 10. Whilst the parley was proceeding (during which time the cavalrymen would have been shot down, had it not been for the truce, especially as some of the cyclists were well posted inside a building) a cyclist messenger was seen approaching from the direction of Ash. Seeing him the six cavalrymen shouted "Here is one," and dashed after him. There was an exciting pursuit but the cyclist escaped; he threw his machine into a ditch and jumped over the hedge into a wood, where the cavalry could not reach him. Watching his opportunity, he jumped back into the road, recovered his machine, and rode triumphantly into Eastry. In the meantime Colonel Savile, energetically seconded by Mr. Fox, had posted his men across the road with their cycles, forming a barricade, so as to effectually cut off the retreat of the cavalry. They tried to charge, but could not get the horses to face the cycles. Eventually they went off by another way, and were seen to be going in the direction of Tilmanstone; Colonel Savile sent a cyclist orderly to warn Major Carpenter, who with Major Knox-Holmes, a veteran of 80 years, put up an effective defence, partly of cycles, partly of hurdles. They were attacked on all sides, but maintained their defence till relieved by a party of infantry scouts. After that the whole of the left division of cyclists were re-united under Colonel Savile, and came in direct to Dover.

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I should mention that Mr. Perry who was in charge of the party that went through Wingham and Ash, bearing in mind the instructions that the cyclists were to use their common sense, and knowing that he was to search for the enemy, mounted the church towers, and surveyed the country from the top. Major Craigie with the advanced guard when approaching Dover encountered His Royal Highness the Field Marshal Commanding-in-Chief, who appeared to take great interest in the cyclist operations, and asked to see what they could do. The nearest man, who happened to be one of the very best of the party, Mr. Rucker, well known in the cyclist world, was despatched by His Royal Highness across country to a hill in the distance. The ground which His Royal Highness selected, comprised a steep descent, also woods, gates, ploughed fields and grass. Mr. Rucker ran over the ploughed field with his machine (a Rover safety) across one shoulder, and riding full tilt, when he could, up hill and down hill, arrived at the top, having gone at an average pace of about eight miles an hour. It was considered that a good horseman could not have done the distance in the time. Mr. Rucker entirely disclaims any special credit as due to himself, and maintains that any one else in the corps could have done as well. His Royal Highness was much impressed by Mr. Rucker's feat, and intimated it to him on his return. For such work the "ordinary bicycle" would be inapplicable.

On Sunday afternoon the whole Cyclist Corps assembled on the top of Dover Hill, in order to practise for the march past which was ordered for Monday. The ease with which the cyclists took up their dressing was a subject of general remark. It was the same the next day in the march past before the Duke. There were four companies, namely two of ordinary bicycles, one of safeties, and one of tricycles led by Major Knox-Holmes. The tricycles were ridden. The ground was too rough for the bicyclists to have ridden at a uniformly steady pace so they marched past on the left of their machines. On the way to the march past I saw one man ride up the whole of Dover Hill against the wind. I was informed that others did the same next day. After the drill on Sunday afternoon Colonel Stracey wishing to send a dispatch to Walmer, called for volunteers from the corps. Two men did the distance, 5 or 6 miles, in about 25 minutes against the wind. I should like to tell you something of what cyclists are capable. I have a few notes of records,—5 miles within 14 minutes; 50 miles in little more than 2½ hours; 100 miles in 5 hrs. 5 mins. 5 secs. Those were done on the track. But although the same pace cannot be obtained on the road, yet a very good average can be made of 10 or 12 miles an hour. A good cyclist would think nothing of doing 200 miles in a day. The veteran Major Knox-Holmes has lately stated to a high military authority that he would undertake, at 48 hours notice, to find 200 men who would cover the distance from London to Portsmouth in 12 hours in heavy marching order: also that he, on a tricycle, would though 80 years of age, ride further in 24 hours than any cavalry regiment has ever ridden in 3 days. This is not bombast; it expresses forcibly what is perfectly practicable. Whatever use is to be made of cyclists for military purposes it must be such as to depend on their

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powers of covering long distances in short periods of time. Cyclists are undoubtedly suitable for orderly duty within interior lines of communication. Of that there can be no doubt. I have shown you that they are fitted for connecting the advance of parallel columns, because, however rough the roads or lanes may be, a cyclist will contrive to get along at a good pace, for he will often come across places where he can ride, and a good cyclist will ride along extremely narrow ruts. For rapid scouting, such as we practised in these manœuvres, I think cyclists are well adapted. I do not want to substitute cyclists for cavalry, I want them to be additional to cavalry. Cyclists can travel faster than cavalry, and cyclists can ride forward with all the more confidence if they know they are supported by cavalry in their rear; we may want to advance some men of our force as fast as possible to requisition villages, to destroy telegraph wires, to break up railways, bridges and boats—cyclists can do all this. Cyclists are less exposed to view than cavalry, they make no dust, they present a smaller mark to the rifleman. Machines are being constructed with fittings for carrying rifle and bayonet, so that cyclists may act as mounted infantry. Moderate weights packed on the machines are of trivial consequence, except for racing. All necessary supplies can be easily packed on tricycles or safety bicycles. It is my belief that cyclists will play an important part in the next European war. A cycle is usually regarded as a machine of great delicacy: so it may be, but it is far less delicate and costly than a horse, also more easily repairable. I consider it waste of a good cavalryman to use him and his horse for orderly duties.

A few cyclists armed only with revolvers, would be quite sufficient to requisition an unarmed village. We saw in the Franco-German war how the Uhlans in small parties of twos and threes were able to put villages under requisition; cyclists could do the same. I have not sufficiently considered the question of employing cyclists in large bodies as mounted infantry, to be able to give a decided opinion, but I see no reason why, if necessary, a force of 1000 or 2000 men should not be advanced on cycles. I have made calculations about the rate of marching. I do not think that more than about 1760 cyclists per hour could easily be moved past a given point, but when it is remembered that their average pace will be 7, 8, or 10 miles on hour, it will be seen that a very considerable body of men may be moved a long distance. The order of march must be somewhat loose, either in single or double rank, according to the ground. There must be no risk of collisions. When going rapidly longer intervals must be kept, so as to prevent crowding when a slower pace becomes unavoidable. The capabilities of the individual men must be carefully considered if the greatest use is to be made of them.

Commanding Officers must remember that their men should not be kept standing when heated, the exercise being of a severe description. The cyclist when left to himself knows what care is necessary as regards health and food; I fear for him when subject to red tape.

With regard to the question:—Who are to form our military cyclists? It seems that with Englishmen everything that prospers starts rather from individual enterprise than from government initiation,

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I think therefore that we have to look more to our volunteers for cycling than to our regular forces. I see at present considerable difficulty in introducing cycling into the army, in providing Tommy Atkins with a bicycle and teaching him to ride it. Yet the Germans do it, and what other nations accomplish is surely practicable for us. But I do think that time may be saved, and the use of cycling made manifest more expediently at present by commencing with the volunteers under military encouragement. The volunteers can never be considered otherwise than an adjunct to the regular forces, and therefore whatever effectual good may be done by them must be with the sanction and encouragement of army officers. And this is what I wish to plead for to-night—that we of the army should encourage this movement; should, above all, not unduly disparage it nor ridicule it. Let it have a fair trial, and let us congratulate ourselves that there are men willing to expend their money, their time and their labour in raising such a force. I allude chiefly to the corps of cyclist guides proposed to be raised by Major Carpenter, whom I am glad to see here to-night, and who intends to make thorough military efficiency, including a practical knowledge of army signalling, a necessary condition of enrolment.

Surely this movement should be made a grand success. There is a large body of cyclists in England, strong athletic men, thorough Englishmen, selected from amongst the most orderly classes of society. If they are ready to exert themselves for the defence of the Empire, we should encourage them to do so (hear, hear).

Welcome them then, not only as fellow citizens, but as brother soldiers, united with us for the defence of our Empire, and the glory of our Queen. (Great applause).

Colonel Savile.—Colonel Taylor, Ladies and Gentlemen; I was very glad to find when I entered this room this evening that it is not proposed to limit the discussion to the operations of the cyclist corps during the Easter manœuvres, because I consider that their employment on that occasion was of an entirely exceptional character—of a kind which I hope will never occur again. I mean that the cyclists were then employed to replace cavalry, a use which is very foreign to their true functions. Consequently I think that the examination and consideration in full detail of the cyclist operations in Kent can hardly be very interesting to any except those who were present, and that they do not convey any very useful lessons for the future. But although I am strongly opposed to using cyclists in place of cavalry, I do think that there are certain ways in which such a force may be employed in war. I am convinced that one of the most important military problems of the present day is to determine in what manner infantry marksmen can be moved quickly from one point to another in a theatre of war. It is a matter which, if it can be satisfactorily solved, would add very considerably to the strength and efficiency for fighting purposes of the side which first finds the solution. What we have hitherto done on several occasions is to mount infantry soldiers on horseback. This force of mounted infantry has always been hurriedly improvised and organised at the outbreak of hostilities, for experience shows that such a force cannot be maintained in peace time on account

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of its fatal tendency to turn into cavalry. The haste with which such corps have been formed has added greatly to their expense, and frequently the men do not become *au fait* at their duties until it is almost too late. I hardly think that these disadvantages would apply to a permanent cyclist corps. There would certainly be no danger of the corps missing its true function by the reprehensible endeavour to imitate cavalry. Next, a cycle is cheaper to buy than a horse, and costs nothing to keep. I would not, however, for a single moment advocate the use of cycles on the score of economy alone; if marksmen on cycles are not so efficient as marksmen on horses, then I would say have nothing to do with the former. We want to have the best article whatever it costs, and the country can afford to pay for it. I conscientiously believe, however, that a series of thorough tests and trials would demonstrate the fact that the work required of mounted marksmen could be done quite as well—I hardly like, before the trials are made, to say better—by cyclists as by horsemen. Experiments would prove beyond a shadow of a doubt that cycles can travel along roads both farther and faster than horses; it is certain that cyclists could always keep up with cavalry on the march, and how glad any commander would be to dispense with the forage and transport required by a force of mounted infantry. I should like to mention one or two cases in which I think cyclists may be employed with advantage. Suppose that the cavalry screen is thrown forward several days march in front of the advanced guards of the columns of an army, and that some point of strategic or tactical importance, such as a junction of roads or railways, a bridge, a ford, or a defile has to be held until the arrival of the nearest advanced guard. I am sure that men on cycles could easily and rapidly be sent forward to supply the requisite defensive power, and when once on the spot I think they would be more useful and efficient than if they had ridden up on horses. Every man's rifle would be available, instead of one-third of the force being employed in holding the horses. The small safety bicycles lying on the ground would be quite invisible as regards attracting fire, yet they would form a strong obstacle across a road to the passage of cavalry; the riders can keep their steel steeds close to them, and would be entirely free from that natural nervousness which a dismounted man feels on being separated from his horse and losing sight of it. Again, suppose that cavalry are employed in scouting at too great a distance from infantry to be able to rally upon the latter. History shows us that in such cases the freedom and the dash with which cavalry should act are often crippled for want of the immediate presence of a few riflemen. I believe that the delays which often occur in the movements of a cavalry screen might be entirely prevented by the employment of marksmen on cycles, their very great speed enabling them to arrive at the point of contact with the enemy sooner than any other arm could be brought up. Lastly, suppose that the cavalry screen covering the front of an army is numerically weak, then, even if it is to be assumed that a cyclist cannot go across country—although I consider the one great lesson derived from the recent manœuvres is that such is not the case—it is plain that a cyclist corps might assist this numerically weak cavalry by enabling it to cover a wider arc of front; for the work on the roads might be entrusted to cyclists, who can easily keep pace with the cavalry, whilst the latter would scour the country in the intervals between the roads.

At the present moment several interesting experiments are being made as regards the construction of cycles for war purposes. A machine called the "Victoria," built by Messrs. Singer, of Coventry, is now being tested at Aldershot by order of the War Office. It carries ten riders, and I have found by a personal trial that it is exceedingly fast, easy of propulsion, and a wonderful hill-climber; a very large amount of ammunition can be carried upon it without any appreciable decrease in the pace. Several ingenious devices for carrying rifles on bicycles have already been invented, and I do not anticipate the slightest

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difficulty in this respect. Experiments are also being tried as regards carrying light machine guns on cycles, and it is obvious that if satisfactory results are thereby arrived at, the fighting strength of a cyclist force would be enormously increased.

I have only this afternoon heard from Colonel Stracey, who commanded the Dover marching column, that the verdict of the military authorities upon the operations of the cyclist corps at the Easter manœuvres is "very satisfactory." I am sure that this piece of news will be most gratifying to those here this evening who took part in the operations. I think I am justified in believing that the military employment of cycles has now arrived within the sphere of practical military topics, and I consider that one of the strongest proofs that such is the case may be found in the fact that such a notable body as the Royal Artillery Institution has permitted a discussion upon the subject to be held within its walls. In this matter England lags behind the continental powers. Although in this country we have the best cycle manufacturers in the world, more riders, and probably also the best riders in the world, we have so far done nothing to utilise them for war; yet it is well known that in France, Germany, Austria and Italy, the value of cycles for certain military purposes has long been recognised, and the military authorities in those countries have not stopped at mere recognition, but have taken active steps to procure cycles from England to form an adjunct to the forces.

Mr. Lacy Hillier.—Colonel Taylor, Ladies and Gentlemen; I think we ought to be very grateful indeed to you for the opportunity of being heard here this evening on a question that undoubtedly interests every cyclist in the Kingdom. We cyclists have been a little ostracised and outside the pale of civilisation for some time, and I feel sure that the countenance we have received in this matter will do the sport a very great deal of good. The point of speed is one which of course it is very difficult to estimate when you come to move large bodies of men together. Individual speed is one thing, and the speed of masses of men is another. If you take running or walking records, or, in fact, any records, you will be perfectly unable to draw any parallel between them and the speed which would be attained by large bodies of men. At the same time the rapid pace which can be obtained on the bicycle, or the tricycle, or the safety bicycle, whichever you choose, must certainly affect the speed of the movements of a large body of men. In cycling clubs of late, we have not gone in very much for drill, but at one time, in London especially, it was a very great feature, and there was a great deal of drilling among London Clubs, and we were able to get along very well, and I think made a very fair appearance, riding always in pairs. It was generally found that if a judicious officer was at the head of the club, keeping a judicious pace, we could get the slower men along much faster than they could get along by themselves; and if we held one or two of the fast men back it did not do them very much harm, while it assisted the others. Therefore we were able to move a good number of men pretty rapidly.

As showing the speed which can be obtained on the bicycle, I will take a few instances:—The first instance is the mile record, that now stands at two minutes thirty-four and a fraction seconds, but it has actually been done in very much nearer two minutes and a half. There is no doubt that that is a fair quotable record at the present time. Now two and a half minutes for a mile is a rapid pace, as I think you will admit, and if a certain number of men were trained they could approach to something like a proportion of that speed, although, of course, they could not hope to attain that speed as a body. On the tricycle the record stands about 2 minutes 41 seconds. As to longer distances 21½ miles have been ridden I believe in America, on a bicycle, in an hour; and on a tricycle in England 20 miles. Of course, all those records are made on specially prepared

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tracks, and it is very difficult indeed to say what pace would be got by a body of men. On the road we have had 295 miles and a fraction ridden in the 24 hours by an individual. Of course that is an exceptional thing; it could not possibly be done by any body of men; but then at the same time it may be taken as a ground to work from. My own opinion in the matter is that if a certain number of men were got together, and went into proper drill and training to bring them all about equal in condition, they could average a very long day's journey, with a considerable amount of weight on the machine. The actual amount that can be carried on a machine is not perhaps thoroughly appreciated, because there are a great many people who do not take the trouble to stow baggage upon their machines. I can quote a case in which, on a tandem tricycle, a rider took a passenger, nine stone in weight, and carried her 60 miles inside 14 hours comfortably. She never did any work at all, she simply sat in front of the tandem, and he covered the 60 miles inside the 14 hours for pleasure. It was not hard work but merely pleasure. Of course that is an exceptional weight to carry. But I think that something like three or four stone might be stowed upon a rear driving safety bicycle. A long thing like a rifle will compare very well with the tripod of a photographer, and a friend of mine carries his tripod on a safety bicycle. It is stowed there without any inconvenience at all, and rides very easily indeed, and I think an ordinary safety bicycle would take a rifle very comfortably. There are many other places where luggage could be put on, and things carried for the convenience of the rider, and if he were trained to ride with a weight on his machine, he would not feel it after, say, a weeks use. When these manœuvres were going on I was, unfortunately perhaps, away in France touring, and I had a large package, I might have had perhaps 15 lbs. on the machine altogether, and I never noticed it at all after the first day. Of course when I got the weight off again and went out on the machine without the luggage on, it was very noticeable for a while, but still the weight during the trip was not a very great disadvantage, and of course it might have been very much increased. There is one other point that has been mentioned with reference to the roughness of roads over which machines can be taken. We have never had a proper test, except in very exceptional cases, of how rough a road a man could go over if it was his duty to do it. The owner of a bicycle, especially if it is a new one, at this season of the year, does not for preference take to bad roads, and he does not ride across country under ordinary circumstances, but he rather saves his machine and takes care of it. But if a soldier was mounted on a suitable machine built specially for the purpose, I think there are very few things which would stop him, there are very few things indeed short of a stone wall which would prevent his going across the country. One gentleman here has already done something across country, but I believe when it comes to a question of drill the cyclist could get across almost any country, and as long as there was a lane or cart track of any sort it would be very easy to do it. I do not know whether you have seen the cross country roads in France. On one occasion we came across one in the course of the tour, and ten of us rode along it. There were only about four inches where it was rideable, that is where the wheels had gone, and we found that we were able to go along there for a considerable distance before we touched the main road again. Therefore, I think the capabilities of the machine, if put to a proper test—the men having had proper drill—would be very great. I do not think they would be able to compete with cavalry or other regular troops except on their own merits as a separate body. As scouts it has already been shown they can work; and I think as messengers and so forth they would be sufficiently capable. Although we as cyclists ought to be very thankful to those men who went out on their first review for doing so well, still at the same time I do not think they have given you any real idea of what cyclists could do if they were properly trained. A week's notice I do not think is enough. If they were

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MAJOR CRAIGIE.—Colonel Taylor, Ladies, and Gentlemen; you have already heard so much, both from the military and civilian point of view, upon the subject that I do not think I can add very much to what has gone before. But there is one point that I should like to direct your attention, which I think has hardly been touched upon this evening, and that is the particular work cyclists might do in carrying messages. I cannot say the point has not been touched upon, but it has not been gone into very much. I had been thinking a great deal about the employment of cyclists with an army before I heard of the employment of them at Dover, and I have taken the trouble to compare certain work done by cavalry with what might have been expected from cyclists under similar circumstances. I have taken three particular cases of long distance rides by cavalry. Two of them were performed by Russian cavalry and the third by English cavalry. In the first case, a small body of Russians—I have not got the exact numbers,—rode 105 miles in 38 hours. Of those 38 hours they were 20 hours on the road, and they averaged $5\frac{1}{4}$ miles during their riding time. The other body of Russian cavalry did slightly better. They did 149 miles in $40\frac{1}{2}$ hours, of which they were $27\frac{1}{2}$ hours on the road, and they averaged $5\frac{1}{2}$ miles. Then came an attempt of a similar kind in England, which was carried out under the orders of Sir Evelyn Wood, at Colchester, during the last Autumn, if I remember rightly. A party of the 13th Hussars, one officer and one N.-C. officer and four men with one horse and a led horse were directed to ride from Colchester to Norwich and back. The distance was $137\frac{1}{2}$ miles; they took $68\frac{1}{2}$ hours going there and returning. They were 20 hours 39 minutes on the road, and their average came up to $6\frac{3}{4}$ miles an hour. This you see was the best example of the three. The roads, I fancy, are very fair in that part of the country, especially for cavalry, and the horses were in pretty good training. I think they were specially fed and looked after for about 10 days or a fortnight before the march so as to get them into hardened condition, and the account at the end was that they came back in very good condition. They evidently could do the work easily. But what did they accomplish?—$137\frac{1}{2}$ miles in $68\frac{1}{2}$ hours. This is, I believe, the best record of cavalry at long distances. They were supposed to be carrying despatches through a hostile country,—a country perhaps clear of the enemy's troops, but in which the population was hostile, and it was important that these despatches should be carried through to the other army and the reply brought back as soon as possible, so that they were not to spare their horses at all in going and coming back. Now to compare with that I will take a body of cyclists. We will suppose there is one officer; I will assume in this case that the men are mounted on tricycles, so as to take the most unfavourable case, looking at it from the point of time, and we will say one officer on a single tricycle and the sergeant and five other men on three tandems. We will suppose they start at 6 a.m., keeping up the same hours every day, ride 12 miles and halt at half-past 7,—I am giving an average of only 8 miles an hour of their riding; starting again at 9 a.m. and ride 20 miles; halt at 11.30; start at 1.30 p.m., and ride 20 miles; halt at 4 p.m.; start again at 5 p.m., and ride 16 miles, halting at 7 p.m. They

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would have ridden between 6 in the morning and 7 in the evening 68 miles. During that time, taking it very easily all cyclists will allow, they could easily do 68 miles. If they kept this up for three days, by 7 p.m. on the third day they would have done 204 miles in 61 hours. The cavalry did 137½ miles in 68½ hours. So that, you see, taking a very ordinary case—a case which any ordinary rider who had been on a machine a week or two could do—they could accomplish I think something like half as much again as cavalry; and I am sure if you take some of—I will not say our best riders, but some of our fairly good riders in the country, such as a few of those we had with us at Dover, they could do something like two and a half times, or even three times as much as the cavalry could do in a day. I think that is a thing upon which cyclists might very well be employed. There is this advantage over employing the cavalry, that you do not require to detach men from a combatant unit. Fancy a cavalry regiment sending off one of its smartest officers and five or six of its best men and some very good horses. If that is done, it mars the efficiency of the regiment a good deal, and I think any commander would complain, and would rather have his men with him. If you have a very small number of cyclists you will be able to carry on all the despatch work and keep up communication between the different columns or between different portions of large forces in cantonments or bivouac, or even on the line of march, between the cavalry screen in front of your columns and the main body. I think that is a matter in which cyclists might be used with very little expense to the country and without interfering with any other use for which mounted men have to be despatched. Then, again, with regard to forming a corps for military use entirely; for use at home there would be nothing like the Volunteers. We have got a splendid force—men who are most of them full of energy and zeal, and I am quite sure the thing has only to be mentioned among the Volunteers to ensure plenty of recruits, and probably very good recruits. But if we are going to employ cyclists at all for operations on the Continent—we cannot take our Volunteers beyond the seas: they are not expected to serve out of the country—I think we ought to have a certain nucleus of a military corps of soldiers; cyclists might very easily be employed in particular garrisons and head-quarters such as Aldershot, the Curragh and Portsmouth, and other places where you have regiments quartered, in carrying messages backwards and forwards. It is very poor employment for a cavalry soldier who has got a valuable horse to be travelling backwards and forwards like a telegraph boy; whereas, cyclists would not think it derogatory to carry messages about, and the machine would be very little the worse at the end of several weeks hard work. I put that as a point which may be taken up by the authorities when they come to consider cycling from a military point of view. (Applause).

MAJOR MASCALL, R.E.—I should like to ask how the machines stand going across country. We have heard some very wonderful things done by riders, which I had no idea could be done, of men going across ploughed fields. Now I should like to hear how the machines stand it, whether a machine that does work of that sort will not be thoroughly knocked up and done for. I think that the great speed done by cyclists is in great measure at present due to the great delicacy of the machines and to the extreme lightness of their construction, and the beauty of their mechanism generally; but it seems to me that these machines might very easily be put out of order by rough work.

THE CHAIRMAN.—Probably Mr. Lacy Hillier will answer that question.

MR. LACY HILLIER.—The point is simply this. Of course, now-a-days, machines are made exceedingly light, and each one's individual effort is to get one as light as possible. But I should say that by adding judiciously 5 lbs. of extra weight (in the shape of thicker spokes, a gauge, stouter tubes, &c.) to the lighter

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standard pattern supplies now on the market, they would be calculated to withstand the severest tests, whilst the retarding effects of such an additional weight would be scarcely appreciable upon the road. Now and then you have a nut come loose, but a machine made a trifle heavier would stand for any length of time, it would, as a matter of fact, stand the hardest work it could be put to.

THE CHAIRMAN.—Major Carpenter will kindly tell us what passed between himself and the War Office as to the formation of Cyclist Corps.

MAJOR CARPENTER.—I have left the service, but I belong to the Army Reserve of Officers. Being the senior officer employed with the force of cyclists I naturally took great interest in what was taking place. I went to the War Office and I was introduced to Colonel Freeman—General Freemantle I think it is. By his advice I sent in a formal application. I was told there was very great diversity of opinion upon the subject after what had taken place at Dover, and that many officers thought that it would be better to have sections attached to each Volunteer battalion rather than have a corps formed. Others had a contrary opinion on the subject that was under consideration, and that in fact it was likely to be so for some little time, but I sent in a formal application with other friends asking permission to endeavour to raise a force of cyclists. Applications have come in since from many of our friends who were down at the Dover manœuvres and also from others. In fact applications are coming in every day from gentlemen wishing to join the force, and when a certain number has been reached I am informed that then I must again make application to the Horse Guards and it will be further considered. That is all I have to say.

THE CHAIRMAN.—Has any other gentleman any questions to ask?

I am sure it is your wish that I should convey to Colonel Kensington your thanks for his very interesting discourse and also for having brought forward this subject, which appears to be a very important one, and we are also exceedingly obliged to our visitors for the light they have thrown upon the question. (Applause). It appears to me they have made out their case of the great value of cyclists as messengers and for service generally within the lines; I own, however, that personally I am not quite converted to the idea that they could be used as an offensive force, but possibly that will come with time when one knows more about it. I should rather gather from the answer to the question which was just asked as to the machines, that the machines at present in use will not stand this rough country work, and I should imagine that the heavier machine which has just been described would probably not be as fast as the present one and that probably we should have to take a considerable percentage off the pace. But we have not yet heard that this heavier machine has been constructed. I do not know whether Mr. Lacy Hillier could tell us anything about it.

LIEUT.-COL. SAVILE.—I may be allowed to say that the machine I ride is a fairly light one, only weighing from 35 to 40 lbs., and I have taken it over extremely rough roads at a great pace, and again at a great pace down hill—about a mile in four minutes, that is the pace I generally travel on favorable ground, and it has stood everything perfectly well. May I say that the machine which Mr. Rucker rode before the Duke of Cambridge at Dover was an ordinary roadster. It was not a racer at all. It was a machine ridden in the ordinary way up and down hill over every kind of road, it was by no means a racing machine, but one weighing about 35 lbs. Of course a racing bicycle only weighs about 31 lbs. It has stood the roughest work, and had a very large amount of luggage carried on it.

THE CHAIRMAN.—I think we may conclude our proceedings with thanks to Colonel Kensington and our visitors.

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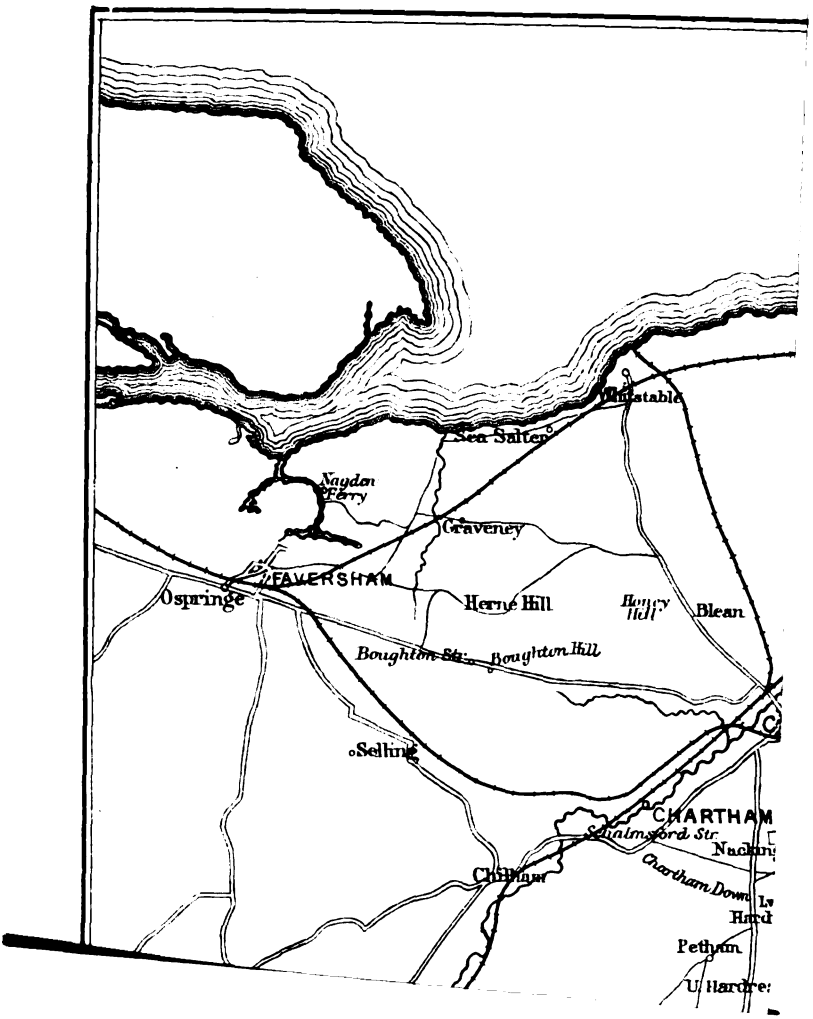

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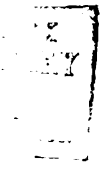

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THE OFFICERING OF THE ARTILLERY MILITIA.

BY

CAPTAIN F. W. PANZERA,

2nd (Militia) Brigade, Cinque Ports Division, R.A., and Army Reserve.

In venturing thus to offer a few remarks on the officering of the Artillery Militia, I trust I shall be forgiven for—what must appear—the "cheek" of attempting to offer any suggestions or to express any opinions upon such a weighty subject.

I have had exceptional opportunities of seeing where the shoe pinches, having served with three of the best Artillery Militia brigades, as well as with the Royal Artillery, at altogether ten stations in England, Ireland, and the Channel Islands.

Some of the happiest days of my life have been spent with the R.A., and I should like to take this opportunity of expressing my feeling of deep gratitude for the hearty kindness and truly friendly courtesy with which I have been treated by every Royal Artillery officer, without exception.

There are surely many reasons why the difficulty of officering the Artillery Militia with men suitable for the position and likely to become *efficient Artillery officers* is a very serious matter.

It is admitted, I believe, on all hands that the present establishment of Garrison Artillery is insufficient to meet even the normal peace requirements at home and abroad, and if we were engaged in any war, no doubt a number of Militia brigades would have to be embodied immediately for garrison duty to enable the Royal Artillery to provide the necessary force for siege and mountain batteries, to say nothing of drafts to Field and Horse Artillery.

I believe—and I speak with great diffidence, but from experience with R.A. Service Batteries as well as with Militia—that the *men*,—being as a rule of good physique, and strong and hardy,—would, in a few weeks, be fit for any duty they might be called upon to perform; indeed, in some Brigades the discipline is so strict and the instruction is carried on so earnestly that the men are quite fit for any garrison duty at the end of their 27 days' normal annual training.

To bring the men to a high state of efficiency, however, during

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their all too short annual training, and to get the most out of them and be able to maintain the stringent discipline which is absolutely necessary to secure a satisfactory result, it is a necessity, theoretically, to have a staff of earnest, energetic, and highly-trained officers, possessing a *thorough practical knowledge* of their various duties, and able, by their personal influence and example, to imbue the men with a feeling towards them of confidence and respect.

I am afraid that officers possessing in any high degree the above qualifications are in the minority at present, and that they will necessarily remain so (at any rate in peace time) under the existing system.

There are many reasons at present why young men prefer an Infantry to an Artillery Regiment of Militia.

Three classes of young men join the Militia :—

First. Men of means, with no particular soldierly instincts, who simply join for the sake of the mess life, the swagger (too often) and gaiety of a county training. For these obviously a *good* Artillery Brigade has few attractions, for there is very little entertaining, and every available hour of the training is devoted to soldiering and real work.

This class would, I should say, be considered by an Artillery commanding officer the least desirable, and their holding aloof would appear, from his point of view, to be no great loss.

Second. Young men who are desirous of obtaining commissions in the Line through the Militia, the majority being sons of military and naval men.

These from a commanding officer's point of view are "necessary evils," they are migratory, and unless naturally very keen and conscientious are apt to be rather slack in their militia work, looking upon their Militia Regiment as merely a stepping stone to the Line. Nevertheless *without* the inducement of Line commissions the junior ranks of the Militia would be almost vacant.

Now, in this respect, the Artillery is very heavily handicapped, deriving, as compared with the Infantry, very little benefit from the inducement offered by the possibility of obtaining a Line commission.

The reasons are self-evident; a man joining the Artillery would not be able to make use of one scrap of his Militia uniform on eventually passing into the Line, whereas if he joined the Infantry the whole of his outfit would come in with a few trifling alterations. Again, he looks upon the time spent in learning Artillery drills, &c., as wasted.

Third. We now come to men who join the Militia intending to stay in it. Many of these are men whose fathers and grandfathers have been in the Service, who have from childhood been amongst soldiers, and who have, in many cases, been brought up for the Service themselves, who have been prevented from some cause from joining, but who are keen soldiers at heart, and who would "give their ears" to be permitted to serve anywhere at home or abroad.

The best of these officers endeavour earnestly and unostentatiously to make themselves efficient by availing themselves of every means

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the authorities place at their disposal, with the earnest desire and hope of being *employed in time of war*, and the chance of *temporary employment* in peace time is a *great inducement* to this class of officers to join the Militia, and also to remain in it.

Now in this case the Artillery is again seriously handicapped, for while *Infantry* Militia officers have for years been employed—and are still employed—at Infantry Regimental Depôts at home, Artillery Militia officers are only made use of during some scare. The first time Artillery Militia officers were permitted to do duty with the Service batteries was in January 1885, a small number being kept on until October of the same year. They were re-employed from January, 1886, until the beginning of this year. I was, however, the only Captain employed in 1886-87, and now the authorities state that "it is not intended to employ officers of Artillery Militia during the current financial year."—Why?

Now taking the cases I have mentioned :—I will propose no remedy in the *first* because I venture to think that—in the Artillery—we are better without the class of men referred to.

In the *second* case I would propose a remedy which will doubtless be considered a most startling innovation, and which will, I fear, try the patience of some of my readers. I trust, however, that after they have exploded and cooled down they will give it a few moments quiet consideration.

My proposal is that under certain conditions officers of Artillery Militia should be permitted to compete for commissions in the Royal Artillery. I would offer a certain number of commissions annually under, in the main, the same conditions which govern the present competition for Infantry commissions, with the following differences :—

That officers should pass the *Woolwich* Preliminary, should qualify in the subjects of the *Woolwich* Further (or entrance), and should *compete* in the subjects of the *Woolwich* Final. I would further make it a *sine quâ non* that officers presenting themselves for the "Artillery competitive" should produce "P.S." certificates from the Royal Military Repository in addition to the certificate on Army Form E 527.

I do not think the Royal Artillery would suffer by this arrangement, and I am sure the Artillery Militia would gain immensely, as one of the greatest difficulties now in the way of obtaining officers would be removed. Officers joining the Royal Artillery in this way would do so with some knowledge of practical Artillery work and interior economy, and with a good knowledge of the subjects usually learned at the Royal Military Academy, but the latter would be acquired *entirely at their own instead of at the public expense.*

I have had some years experience as a successful instructor of fortification, topography, law, and tactics, for the "military competitive" examinations (as well as Staff College); and I am sure Militia officers learn as much of those subjects as (and in *many* cases acquire a more thorough knowledge of them than) cadets at the R.M.C., Sandhurst, because the militiamen are preparing for a *competitive examination*, while the cadets have only to *qualify*.

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With regard to the *third* class I would most earnestly urge the advisability of making some alterations in the existing regulations by which—at very little expense to the public—the efficiency of Militia Artillery officers might be *immensely* increased.

Take first, "Instructors of Artillery;" officers are permitted to pass through a three months' course at the School of Gunnery to qualify as instructors to their brigades. I think I may venture to quote my own case in referring to the extension of the present means of obtaining instruction which I would advocate. I went to the School of Gunnery after having spent three months at Woolwich, and having also already spent nearly six weeks altogether at Shoeburyness as a member of the National Artillery Association. I had also spent two months with an Infantry regiment of the Line, and was for various reasons (previous scientific training, &c.,) able to settle down *at once* to work and to take full advantage of the privilege and make the most of it. Since leaving Shoeburyness in December 1881, I have been constantly soldiering and so employed (as an instructor at a Crammer's, &c.,) as to see "Army Circulars" and "General Orders," and "List of Changes in War Matériel," &c., and I have had the further advantage of an annual visit to the Arsenal with the courses under my instruction.

Now *with* all these *very* exceptional advantages I have been able to keep myself fairly up to date. So rapid are the changes in Artillery that one must be prepared to learn something every day of one's life and must *never* rest satisfied with knowledge acquired.

Now let us consider the Militia Artillery officer enjoying only the *ordinary* facilities for acquiring information and keeping himself posted up in Artillery changes.

He may be selected to proceed to the School of Gunnery to qualify as Instructor of Artillery; after completing his course he attends annually the training of his brigade, but for eleven months of the year he is forced to mark time, and during the training itself, if his regiment is a good one, he has very little time to look up "Changes," &c. What is the inevitable result in nine cases out of ten? Why, that in five years he is probably *utterly behind the times*.

I maintain that some of the exceptional facilities I have enjoyed should be within reach of *every* Militia Instructor of Gunnery. To secure this end I would propose that he should be permitted to attend for a *second* short course after an interval of four or five years. Also that a captain holding an instructor's certificate, and being otherwise satisfactorily reported upon, should be *always* eligible (during peace as well as during war scares, &c.,) for employment with the R.A. *Depôt* batteries; Infantry Militia officers are always thus employed, and such employment of Artillery Militia officers would, I know, be a very strong inducement to this most useful class to join our branch and remain in it; and it would—while affording them the opportunity of acquiring knowledge which they would afterwards disseminate in their own brigades—free captains of Royal Artillery from work not too agreeable and render them available for more valuable service.

With regard to subalterns, all important Artillery stations are short of them, and I would urge most earnestly the advantage to the Militia

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of permitting again their temporary employment, at any rate during the drill season, in the many cases where there are paper subalterns, &c. I would, however, venture with all humility most strongly to advocate that only *thoroughly efficient* officers should be selected, and that none be employed whose age exceeds 28 or 30 years. I know personally from many sources that this question of *employment* does very considerably influence many of the best men in their selection of Infantry rather than Artillery Militia.

Again, it would be very little expense to the public if two Militia Artillery officers per annum were allowed to go through the *long course* as supernumeraries. Officers of the Royal Malta Fencible Artillery are permitted to join this course, and considering the certain employment of Artillery Militia in time of war, it would be an incalculable advantage for each brigade to have one or two of its own officers thus trained.

Lastly, surely all officers should be *encouraged* to use every means to learn their duties and to render themselves as efficient as possible, so as to be qualified for duty with embodied militia or when privileged to serve temporarily with the R.A. To this end why not permit them to pass *any* of the service examinations *provided* the permission *throws no expense upon the public?* When I applied for permission to present myself for "the examination as laid down for Captains of regular forces before promotion to rank of Major" ("A.B.C. and D."), my application was granted as a "special case." While very grateful for this permission, I would ask why there should be any hesitation about admitting officers to *any* examination, provided the fact of extending the privilege to them did not put the authorities to expense or inconvenience.

I must heartily apologise for the length of this paper when space in this journal is so valuable. I am afraid also that I have descended into egoism, but in the latter part of my remarks I felt I could best illustrate my arguments by comparing my own peculiar advantages with the hinderances the majority of officers—equally zealous and keen in their love of soldiering, and more able but less fortunate than myself—meet with in their desire for greater opportunities of acquiring professional knowledge.

In conclusion I would offer my most grateful thanks to the Committee for allowing me the great privilege of publishing this paper in the "Proceedings."

HARWICH, *9th June*, 1887.

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THE QUESTION OF DRAUGHT IN MOUNTAIN BATTERIES.

BY

CAPTAIN W. L. WHITE, R.A.

In my essay on Mountain Artillery, I touched upon several controversial subjects on which, from want of space, I was unable to enlarge or even to justify myself for the opinions put forward. One of the most fiercely contested questions among mountain gunners is the subject of draught, and in these notes I propose to try and defend the position I have taken up in the dispute.

Shafts for mountain batteries were eliminated from the English equipment after the Abyssinian Campaign of 1863, and if the reader will take the trouble to refer to "List of Changes in War Material," para. 1146, he will there find a woodcut which will probably give him a better reason for the withdrawal than anything I can write. These shafts were clumsy in the extreme, and as they were never used in Abyssinia, on account of the excessive roughness of the country, their withdrawal was probably hailed as a blessing at the time, and no man stood up for their retention. In the campaign of 1878, in Bosnia, the Austrians likewise found no use for their shafts, but, these being of a light and handy pattern, they still form part of their equipment.

The French experience is instructive. After the campaign of 1823 in Spain, shafts were withdrawn from the mountain equipment but were reinstated after further campaigning experience. In Algeria in 1841 we find this mode of transport habitual; it had indeed been carried to such an extent that when on entering a difficult tract, pack transport became imperative; after seven or eight hours the mules got sore backs, the stuffing of the pads not having been properly attended to, and the animals having become unaccustomed to pack transport. This experience provides one of the strongest arguments to the opponents of draught, but there is a just medium between the two systems, and the following extract of a letter from Captain Beaufort, R.A., then travelling near Kars, in answer to some questions of mine on the subject, gives the Russian view :—

"I was given to understand that at all times when the ground would admit of it shafts would be used. I asked whether their experience showed this to be often the case or only exceptional. The answer was that it was quite the exception not to use shafts. In fact, as a rule, the battery moved when on the march as a field battery using the shafts, and that the pack equipment, while rendering the battery able to move along narrow mountain paths where draught would be impossible, still was seldom comparatively used. The drill appeared to me to be about equally proportioned, and I hardly think that they could be considered 'to play at being field batteries.'"

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This extract seems to me to embody a very common-sense view on the subject and one in which I thoroughly concur.

The fear that mountain batteries, if provided with shafts, would "play at being field batteries" has actually been seriously advanced against their re-introduction into the service. I can imagine the derision with which this idea must be received by mountain battery officers in India. Mountain service does not lend itself to mere parade movements, and in Indian batteries no time is wasted in practising them.

In Beckerhinn's work on Mountain Artillery most excellent drawings may be found of the different shafts in use, and we find them in the equipments of Austria, France, Italy, Russia, Spain, Greece, Servia, and Switzerland. Germany has no Mountain Artillery.

Russia goes a step further in the use of shafts in her Horse Artillery mountain batteries, of which a description may be found in Beckerhinn, and a more recent one in the "Armed Strength of Russia," 1887. These batteries, of which there are three or four in existence in Turkestan and Siberia, are required to keep up with cavalry on the march, to act as Horse Artillery in open country and at the same time to be able to cross any difficult mountain passes. Their armament consists of 3-pr. bronze guns, but these are, by a recent order, to be exchanged for 2·5-in. steel B.L. guns pattern of 1883. In difficult country the guns, carriages and ammunition carts are packed on horses backs, but in open country the guns and carts are put into draught and the detachments mounted on the horses thus liberated. The artillery is thus able to compete with the fleet Tartar on his native steppes or to follow him to his refuge in the recesses of the mountains.

Another argument that I have heard against draught is, "That it is no use relieving some of the mules unless you can relieve all." This is surely begging the question, and moreover I deny the premise. It is of use relieving the first line because they only require relief. The other lines do not manœuvre and their work is not so arduous, but the best answer to the argument is that in no Continental mountain batteries do relief lines exist because sufficient relief is given to the first line mules by the use of shafts. Some records of marches by French and Italian Alpine batteries, now before me, show very high marching powers. Notably a march of 49 miles executed by a brigade of Italian batteries in 22 hours including halts. Also some marches by the Spanish flying columns during the Carlist war of 1872–75.

Major Clavarino of the Italian army is one of the strongest and most eloquent opponents of draught, and lays great stress on the fact that a great saving might be effected in weight, and thus in the number of animals required, by the abolition of the wheels—*vide* drawing of his proposed carriage, attached to essay. But he does not take into account that the saving of one mule per sub-division carrying the wheels would be more than counter-balanced by the introduction of a complete relief line, rendered necessary by the increased labour thrown on the first line by the withdrawal of the shafts.

The general opinion of Europe is in favour of draught under certain

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conditions and restrictions, and the following may be taken as a summary of the chief reasons :—

1. Relief to animals and detachments and the economy arising therefrom by the abolition of the relief line.
2. Enhanced mobility on roads or open country.
3. If any mules are disabled the gun can be drawn by one or two mules and time given for the others to recover or be replaced.
4. It is an advantage to have the gun ready for action when in the presence of an enemy. This may be taken in an especial degree when dealing with a jointed gun. (*Vide* Lieut. Du Boulay's remarks on this subject in narrating, in the R.A.I. Proceedings, his experiences with the 2·5-in. jointed guns at Abu Klea.

For Indian and similar service, while advocating the re-introduction of draught, I do not desire the abolition of the relief line on account of the exceptional nature of the service.

Finally, I will put a case which is certainly practical. A large force is ordered to concentrate from various parts of India on Pisheen. Infantry and stores move by rail *via* Sibi-Bolan and Sibi-Hurnai. Cavalry and artillery will probably detrain at Dera-Ghazi-Khan and march straight to Pisheen by the board military road in course of construction 140 miles in length. Here then is an excellent opportunity for the use of shafts, and as fighting would be improbable along this road, the mules set free and the relief line might carry the extra kits, spare boots, &c., for the men which it is proposed to leave at the base at Quetta before commencing the campaign. The transport would thus be relieved from some of the great strain necessarily thrown on it at such times.

The following is a list of works I recommend to the curious on this subject :—

Die Gebirgs Artillerie in den Europäischen Armeen—Beckerhinn, 1883.

Rivista d'Artiglieria é Genio. December, 1885.

Projetto di Affusto di Montagna a Striscio. Major A. Clavarino.

Alcune considerazioni sull'ordinamento dell Artiglieria da Montagna. General C. Rossi.

Rivista Militare Italiana. March, April, October, 1879.

L'Artiglieria da Montagna. Capt. F. Quaglia.

Le Truppe Alpine nella difesa Teritorialle d'Italia. Col. Bertelli.

Sull' Artiglieria da Montagna. Traino e sommegio. Major A. Clavarino, 1871.

L'Artiglieria da campo in Europa, nel 1876. Major A. Claverino.

Tactica de Artilleria de Montana a lomo. Don Ramon de Salas. Madrid, 1844.

Artilleria de Montana. Don Miguel Vidal. Translated by Capt. Dalton, R.A. Journal U.S.I. of India.—Vol. VIII. Nos. 36, 37, 39.

Memorial d'Artillerie.—Vol. VII.

Revue d'Artillerie.—Vol. XXV.

Austrian and French Mountain Battery Handbooks.

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THE ARMING OF GUNNERS OF HORSE AND FIELD ARTILLERY.

BY

CAPTAIN C. T. ROBINSON, R.A.

THERE are one or two points in the equipment of Horse and Field Artillery which, although they have been discussed in the "Proceedings of the R.A. Institution," might, I think, be brought to the front again with advantage. It is in the hope that some officers of more experience will give their views on these subjects, that I venture to put my ideas on paper.

I think most officers will allow that it is most essential that our gun detachments should be sheltered as much as possible from the accurate fire which infantry of the present day can bring to bear on them. But most of the schemes brought forward for this purpose appear to have been put on one side; the chief objection being their cost, and the extra weight being prejudicial to the mobility of the guns.

I think, however, that considerable shelter might be obtained, without much extra weight or expense, if a simple arrangement was made by which the axle-tree seat, or lid of the axle-tree box, could be on hinges, and raised into a vertical position when the gun was in action. On the present 13-pr. carriage it would only be necessary to have the seat made with hinges at the back and a thin sheet of metal over the springs on to which the moveable seat could shut down. On those guns which have axle-tree boxes, there could be an upper or false lid made of thin steel or wrought-iron.

These shields with their hinges could easily be fixed on all gun carriages now in use; the cost would be very small, and the weight not more than a few pounds per gun, for, I believe, a thickness of $\frac{3}{8}$-in. steel, or $\frac{1}{2}$-in. wrought-iron would be sufficient to stop rifle bullets.

Even in M.L. guns, these shields would afford very considerable shelter, and the formation of the ground would generally afford protection to the lower part of a man's body. Modern tactics require guns to be pushed well to the front, but without some form of shield the losses of a gun detachment must be very great from infantry at short ranges, and I think a shield of some sort is necessary to enable

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the Nos. 1 to lay their gun with that coolness and accuracy which is so essential for effective artillery fire.

Another point I wish to raise is the defenceless state of a battery in action if it is taken in flank by cavalry.

On ordinary field days if cavalry get within 30 yards of a battery an umpire will usually declare that the guns are all captured and presumably the men all killed. Our men are never taught what should be done if cavalry suddenly charging down on them get into the battery. If the gunners were armed and got under the gun carriage I believe they would be perfectly safe from cavalry; but at present, in action, the carbines are on the limbers, and the gunners absolutely unarmed. This seems to me entirely wrong.

I would suggest that the swords of all N.-C.O.'s and R.H.A. gunners be carried on their saddles, and that every N.-C.O. and gunners of both Horse and Field batteries should be armed with a pistol, this I think should be carried on the person, but if that is objected to, two pistols might be carried in leather cases underneath each axle-tree box.

I have purposely avoided the question of arming the drivers, on which point I think much may be said on both sides.

The carbines I think might still be retained on the limbers, and used for guards and for long range firing if necessary.

If the gunners were thus armed and taught to work their guns until the last moment and then get under them, I think they would be comparatively safe from cavalry, while the escort could defend or retire with the limbers until reinforced.

Although I think artillery must have an escort, still I think something should be done to render it capable of defending itself against an enemy actually in the battery, and I think much might be done to render the escort less necessary than it is now.

I trust some other officers will give their views on these subjects, for I think they are of great interest to the officers of the mounted branch of the Royal Artillery.

NEWBRIDGE, *5th July*, 1887.

NOTE

BY

LIEUT. P. E. GRAY, R.A.

MIGHT I invite the attention of officers of the Royal Regiment to the following extract from the Discussion after a Lecture on Equipment, given at the Royal United Service Institution in 1878 by Major Graves, 20th Hussars. Viscount Lord Wolseley, who was in the Chair, said:—"The next point is about Revolvers . . . . . I certainly agree with reference to giving a revolver to Artillerymen; at the

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present moment an Artilleryman is really in a most defenceless condition, for if his Battery is charged, unless he uses his handspike, he has actually nothing to defend himself with. *Every gunner should be furnished with a good revolver.*" The italics appear in the original Report of the Discussion. So strong an expression of opinion from so high an authority must carry weight to the minds of artillery officers who have considered the subject, when so much has been written latterly as to the arming of our *Drivers*. Swords, revolvers, pistols, and carbines have all been, in turn, proposed for them, how little has been said for the gunners, who are practically unarmed,—quite defenceless if suddenly attacked.

NOTE

BY

MAJOR W. SORELL, R.A.

HAVING for some time been intending to write a short note on the arming of gunners as well as drivers of Horse and Field batteries, I was very glad to see the same idea had struck another officer, Major Arbuthnott, as well as myself, viz., that of a carbine slung over the back. I would however propose its being a repeater, either of the Winchester of Spencer pattern, very short and light; after a short trial it could be worn without any discomfort. The American cavalry is, I believe, armed with such a weapon; and I have been told by men who served in the American war, that they carried their carbines with perfect ease. The only time a gunner or driver is likely to want a small-arm is for guard duties, and for personal defence if knocked off his horse, and left nearly alone, when he may have several enemies to face. The carbine should be slightly shorter than the present R.A. pattern, and the present allowance of ammunition, 20 rounds, would be enough. If all gunners (Garrison Artillery as well as Horse and Field) and drivers were armed with the same weapon, in peace as well as war, one great advantage, simplicity of equipment would be gained. If a sword or cutting weapon of some kind be deemed necessary, a pattern something like the Mountain Battery curved sword, or Burmese "dah" would be more generally useful, I venture to think, than the one now in use—which will hardly cut a small bush down, and is eminently unsuited for campaigning.

I trust some officer of experience knowing not only what to expect of men armed with light carbines, but also what to look for from the carbines themselves, will take up the subject.

PYINMANA, UPPER BURMA,
26th February, 1887.

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SIGNS AND MARKS ON MILITARY STORES.

ROYAL LABORATORY.

Sign or Mark.	Signification.
R ↑ L	All stores manufactured in the Royal Laboratory have this mark.
Roman Numeral, I. II. III. IV. V., &c.	All stores have a Roman numeral, showing mark or pattern.
N N	All stores for Naval Service to have the letter **N** projectiles **N** which will be found near the ↑ and date of examination, except case when it will be found on the top.
	CARTRIDGES.
I	Mark or pattern.
R ↑ L	Place of manufacture
17·72-in. M.L.	Calibre of gun.
112½ lb.	Weight of powder.
Prism[1] Black	Description of powder.
¼ CHARGE.	Charge.
I **R ↑ L** **9·2-in. B.L.** **87½ lb.** **Prism[1] Brown** **½ CHARGE.**	See above.
I **R ↑ L** **40-pr. R.B.L.** **5 lbs. R.L.G.[2]**	See above.

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Sign or Mark.	Signification.
I R ↑ L 13-pr. M.L. 3 lbs. 2 ozs.	} See above. Bales containing empty cartridges have similar markings stencilled on them.
I R ↑ L 32-pr. 58 or 56 cwt. D or 7-in. M.L. 10 lbs.	} See above. D denotes Distant or greatest charge for 58 or 56 cwt. guns. } As above. All cartridges have the description of powder with which they are filled stencilled on them, and when filled in Laboratories the monogram of station.*
	CARTRIDGE STICKS.
Top. 12·5-in. II 80 lb.	Calibre of Gun. Mark or pattern. Weight of powder.
R ↑ L 1881 Bottom.	Place of manufacture. Year of manufacture.
	MONOGRAMS OF STATIONS AT HOME AND ABROAD. *Home Stations.*
A A C	Alderney. Aldershot. Chatham.

* Cartridges filled by the Royal Artillery do not have this monogram.

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Sign or Mark.	Signification.
HC	Chester.
aC	Cork.
D	Devonport.
vD	Dover.
aD	Dublin.
E	Edinburgh.
FG	Fort George.
G	Gosport.
G	Guernsey.
H	Harwich.
J	Jersey.
P	Pembroke.
S	Sheerness.
T	Tynemouth.
U	Upnor.
W	Woolwich.
	Foreign Stations.
B	Barbadoes.
B	Bermuda.
C	Cape Town.
C	Ceylon.
GIB	Gibraltar.
H	Halifax, N.S.
HK	Hong Kong.
JA	Jamaica.
K	Kingston, Canada.
M	Malta.
aM	Mauritius.
Q	Quebec and Montreal.

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Sign or Mark.	Signification.
	DETONATORS, TUBES, AND FUZES, ELECTRIC,
	Are painted different colours, which are as follows :—
Red	Denotes—Fulminate of Mercury.
Blue	„ Submarine mining.
Yellow	„ Naval Service.
White	„ Land Service, Low tension.
Black	„ „ „ High „
	All Cylinders containing these stores are painted the same colour as the contents.
	TUBES, VENT-SEALING, ELECTRIC, FRICTION, AND PERCUSSION,
	Are marked with the letters M, V or P.
M	For guns with Vent masking slides.
V	„ „ „ Heads.
P	„ „ Percussion locks.
	WOOD TIME FUZES
	Are marked with the Roman numeral, showing mark or pattern, No. of thousand, and date of manufacture, thus :—
II	Mark II.
140	140 thousand.
7/85	And was finished July, 1885.
	METAL FUZES
	Are marked in a similar manner.
	Time and Percussion Fuzes.
T. & P.	T, time; P, percussion. These letters will be found stamped near the respective safety pin holes.
	Other markings, such as letters and figures, will be found on metal fuzes; they are placed there solely for convenience of manufacture.

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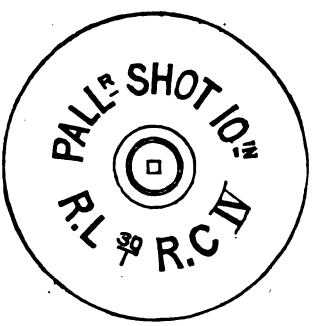
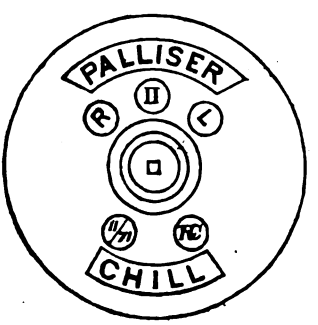
Sign or Mark.	Signification.
	FUZES, PERCUSSION, SMALL, AND TIME AND PERCUSSION, SHORT. I.*
*	Disc of brass ·01 thick over cap composition, instead of paper as in Mark I.
9-in. GUN 6·6-in. Gun or How 13-pr. GUN I R ↑ L	GAS-CHECKS. All gas-checks have the calibre of the gun for which they are intended either cast or stamped on them, thus :—
→	GAS-CHECK, PLUGS, AND NUTS. An arrow, on either gas-check, plug, or nut, shows the direction in which they are screwed into the shell, or on to the plug.
Palliser Shot Base  	MARKINGS ON PROJECTILES. *R.M.L. Studded.* Description and calibre. Place of manufacture, date of casting. The year will be found on the stud. R.C., Ridsdale and Cwmbran iron. IV mark or pattern.
Base.  	Earlier patterns have this marking. Description, Place of manufacture and mark. Date of casting and R.C. iron used. Some have the word SHELL instead of CHILL.

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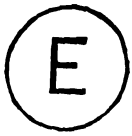
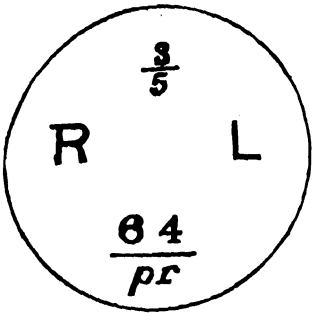
Sign or Mark.	Signification.
On studs. **This refers to all heavy studded projectiles.**	II, mark or pattern. X Studs planed. 11/71, Date of manufacture. ✕ In all but 7″ projectiles previous to 8.3.72, this mark indicates that the studs are of hard alloy.
On rear stud.  **Palliser only.**	Examined at base with pointed hammer to detect weak and porous places. These shell would be made between 1870 and August, 1872. All shell so examined have the hammer mark on base.
	12″ 35-ton projectiles have this marking on the stud to distinguish them from 12″ 25-ton projectiles. Asterisk in addition to Roman numeral denotes that the shell has been altered to take a gas-check. It has the same meaning with all studded projectiles.
U. C.	Near studs; undercut stud holes.
Base. 	Date of casting. Place of manufacture. Calibre. Smaller natures have similar markings.

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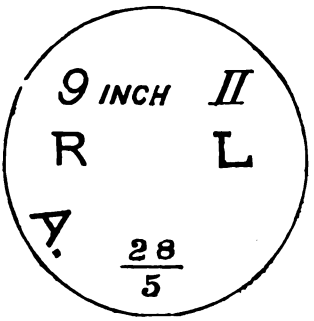
Sign or Mark.	Signification.
Base.  	PALLISER SHOT, STUDLESS, R.M.L. AND B.L. Calibre and mark. Place of manufacture. The A is the work mark by which the "Gang" working on that shell can be identified. Day and month of casting.
On lower band 5/83	Month and year of examination.
	COMMON SHELL, R.M.L., STUDLESS, AND B.L.
Base. **On top band.** R I L 4/86	Same as above. Mark or pattern. Place of manufacture. Broad arrow. Date of final examination.
	B.L. Shrapnel, 5-inch.
II*	* Denotes strengthened head and socket.
II**	** Denotes broad band in addition to above.
	6-inch Light Shell.
L	L to distinguish it from the Common shell. No more will be made; to be used for practice.
E. O. C. A. S.	Elswick Ordnance Company. Astbury & Sons. } Supplied by Contract.

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Sign or Mark.	Signification.
	DISTINGUISHING MARKS.
Red tip.	All Shrapnell shell will be painted with a red tip 1 inch deep.
White band below Red tip.	All steel shot or shell will have a white band, ½ inch wide, painted round the head 1 inch from the top; in the case of Shrapnel this white band will be immediately below the red tip.
C.S. **F.S.**	C.S. will be stamped on the base of cast steel, and F.S. on the base of forged steel projectiles.
Red band.	All filled shell will have a red band, ½ inch wide, painted round the head 1½ inches from the top; in the case of steel shell this band will be below the white band. They will also be marked with the date of filling, and the monogram of the station.*
Bag.	Filled common or double shell will be marked with the word "Bag," if a bag is used, and with a red disc 1 inch diameter, if shalloon primers have been inserted, and with the letter "P," if filled with P and fine-grain mixture.
P.	The colour of the paint will be red on a black ground, or black on a red ground.
W.	Palliser shot (formerly shell) which have been weighted up with sand (§ 5033) will have the letter "W" stencilled on them in white on the head, and also stamped on the base plug.
Yellow band.	Projectiles which are to be used for practice only will be marked with a yellow band round the body.
E in red.	Shells which have been emptied will be marked on the head with the letter "E" in red paint.

* Shells filled by the Royal Artillery do not have this monogram.

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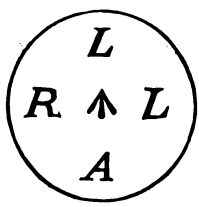
Sign or Mark.	Signification.
	R.B.L. PROJECTILES.
E. O. C.	Elswick Ordnance Company.
I. ↑ A.	Passed into the Service by an Inspecting Officer, R.A.
↑	Some of very early manufacture had this only. All shells so marked may be assumed to have lead and tin coats (the attachment may be tin, undercut, or zinc).
Z.	Zinc attachment.
U.	Undercut method of attachment.
D.	Disc of lead permanently fastened in segment shells; L.S. only.
On base.	Shell with lead and antimony coating made in Royal Laboratory.
	This marking may sometimes be found on shells also having E.O.C. on the apex; it would then denote that the shell had been re-leaded in the Royal Laboratory; and would be found in the cannelure.
	R.B.L. FIELD SERVICE SHRAPNEL.
I*	* Denotes junction of head and body stronger.
I**	** Denotes strengthened head and gunmetal tube.
P. S. on lead coat.	Plain socket.
	TIN CUPS.
L. G.	Low gauge cup.
M. G.	Medium gauge.
	R.B.L. BURSTERS.
B. P. & B. C.	These marks may be found on some of the old Bursters, and denote Brass plain, and Brass concussion.
W ↑ D.	Made by contract for the War Department.

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Sign or Mark.	Signification.
	S.B. PROJECTILES.
White.	Steel projectiles are painted white.
Black, with white belt.	Chilled shot are painted black with a white belt.
H.	Howitzer Case shot has this letter stencilled on them $1\frac{1}{2}$" long to distinguish it.
G.	10" grape which is made up like case has this letter stencilled on it to distinguish it from the case shot.
+	A cross on the plug of S.B. common shell denotes that the thread is tapped throughout to take Pettman's L.S. Fuze.
Red ring round fuze-hole and yellow band.	Denotes that the shell has been recovered, and can be used again for practice only when filled with sand.
	S.A. AMMUNITION.
G. K. **E.** **L. M. C. & Co.**	Kynoch & Co. Eley & Co. Latimer & Clark } Contractors. Cartridges manufactured by the Birmingham S. A. and Metal Co. have no distinguishing mark.
	QUICK-FIRING AND MACHINE GUN AMMUNITION.
	6-pr. Nordenfelt.
S.	Denotes steel shell.
C.	Denotes common shell.
	3-pr. and 6-pr. Hotchkiss.
E.	Lot and date of manufacture is stamped on cartridge cases supplied from St. Denis. Manufactured at Elswick.
	1-in. Nordenfelt.
$	Boxes containing dummy cartridges are painted drab.
S.	Stamped on base of envelope, contract make, Mark III.
	Made in Royal Laboratory, Mark IV.

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Sign or Mark.	Signification.
*	On base of case denotes charge pressed in pellet, enclosed in paper bag, and dense part near bullet.
Special $\frac{410}{80}$ on each packet.	·45" Gardner light for India, $\frac{410}{80}$ denotes 410 grains weight of bullet, 80 grains weight of powder.
	ROCKETS.
C. D. W.	Credenda, Delmard, Weldless Tube Co. } Contractors.
A. M.	Atlas metal. This will be found on old pattern war rockets, and on life-saving rockets.
R. C.	Rocket Case (to guide manufacture). There is also a letter of the alphabet in addition to the No. on each rocket; this changes with every 1,000 manufactured.
	DISTINGUISHING MARKS ON PACKAGES AND BOXES CONTAINING S.A. AND MACHINE GUN AMMUNITION.
ON EACH SIDE. / ON EACH END. / COLOUR OF MARK.	Ammunition for—
E-M.RIFLE — Yellow.	Enfield-Martini rifle, ball.
M-H.RIFLE — Red.	Martini-Henry rifle, ball.
M-H.RIFLE AND MACHINE GUN M-H. CHAMBER INDIA ONLY — Red.	Machine-gun M.H. chamber or rifle, ball.
M-H.CARBINE — Red.	Martini-Henry carbine, ball.
M-H.BUCK — Red.	„ „ buck-shot.
S-B.BUCK — Black.	12 bore shot gun, buck-shot.
SNIDER — Blue.	Snider rifle or carbine, ball.

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Sign or Mark.			Signification.
ON EACH SIDE.	ON EACH END.	COLOUR OF MARK.	
SNIDER BUCK			
		Blue.	Snider rifle or carbine, buck-shot.
CATLING 0·45			
		Black.	Gatling, ·45″ gun.
CATLING 0·65			
		Black.	„ ·65″ „
NORDENFELT			
		Green.	Nordenfelt, 1″ steel.
NORDENFELT			
		Green.	„ „ iron.
NORDENFELT			
		Green.	„ „ dummy drill.
NORDENFELT			
		Green.	„ „ proof.
PISTOL ADAMS'			
		Brown.	Adams' pistol, ball.
PISTOL ENFIELD			
		Brown.	Enfield „ „
PISTOL ENFIELD			
		Brown.	„ „ dummy drill.
MORRIS AIMING TUBE.			
		Black.	Morris aiming tube.

All wrappers and labels for the ammunition bear, in addition to the other particulars, the distinguishing marks shown above, printed upon them in black.

All boxes and cases containing S.A. cartridges or other explosives issued by R.L. to C.G.O., and which are not intended to be opened by him, will have before issue a label (Government Explosives) affixed to them in such a manner that they cannot be opened without destroying the label.

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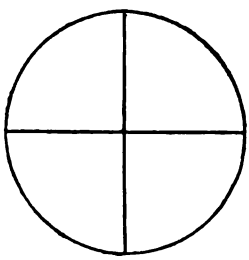
ROYAL GUN FACTORY.

Sign or Mark.	Signification.
	On the face of the right hand trunnion of the 40-pr. R.M.L. guns and upwards, two lines are engraved at right angles, denoting the plane of the horizontal and vertical axes.
	On the face of the left hand trunnion of R.M.L. ordnance is engraved the initials of the manufacturer, the date of manufacture, the number of the gun, and the numeral of the pattern.
12-11-2-0	On the upper surface of the gun, near the breech, is engraved the actual weight, together with the broad arrow. On the muzzle face of the "A tube" is engraved the manufacturer's name or initials, together with its material and register number. Two lines are engraved across the upper surface of the breech, denoting the end of rifling and bore respectively; similar lines are also cut on the R.M.L. 64-pr. guns and

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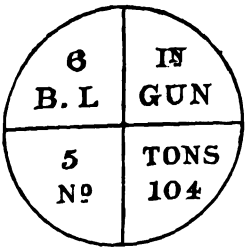
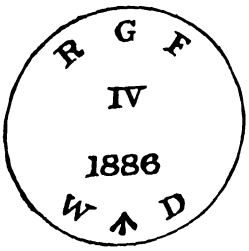
Sign or Mark.	Signification.
	upwards, showing the position of the centre of gravity, and on the 8-inch and upwards lines are cut on the chase denoting the point of "half weight" for slinging the gun.
	On the face of the right trunnion of B.L. 4-inch and upwards is engraved the calibre and nature of ordnance, the nominal weight, and the number of the gun. Two lines are also engraved at right angles in a similar manner, and for the same purpose as those of the R.M.L. ordnance.
	On the face of the left trunnion of B.L. guns is engraved the initials of the manufacturer, date of manufacture, numeral of pattern, and "W.D." with the broad arrow.
	B.L. ordnance has the actual weight of the gun, together with the broad arrow, engraved on the upper surface at the breech in a similar manner to the R.M.L. ordnance.
	The material of the A tube is engraved on the face at the muzzle, together with its register number.
1 1886 R. G. F. 6" B L. III. IV. W. ↑ D.	Where possible the initials of the manufacturer, the date of manufacture, the numeral of the pattern of the article, and the nature of the gun, or guns, to which it belongs, and the letters "W.D.," together with the broad arrow, is stamped in a conspicuous position on each article.

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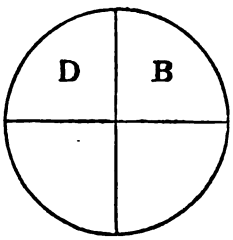
Sign or Mark.	Signification.
	On the face of the right trunnion of the R.B.L. 7-inch is engraved the letters "D." "B.," denoting that the gun is "double bushed." And two lines at right angles in a similar manner to the R.M.L. ordnance.
	All articles manufactured for the Navy are marked with in a conspicuous position.
	The Royal Monogram is engraved on all ordnance.
	Upon all articles will be found the examiner's stamp, denoting that the article has been examined and found suitable for service. The number under the crown is that of the examiner who has inspected the article.
	Upon articles which are condemned as unsuitable for service will be found the "condemned mark." The number under the cross is also that of the examiner who has inspected the article.

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ROYAL CARRIAGE DEPARTMENT.

REGISTER numbers preceded by letters (according to the nature of service as shown below) are attached to all the important services of Royal Carriage Department manufacture, and also contract articles, where not provided with Contractor's numbers.

"Where manufactured," the "War Department Mark," Date of Manufacture," and "Weights," are in most cases also given.

Nature.	Letter.	Examples.	Remarks.
Ordnance Mountings. Iron or steel garrison, (Carriages & platforms).	A	10-inch, 18-ton gun, R.M.L. W∧D II. R.C.D. 1885 Reg. No. A 562 Wt. 67 cwt.	—
		Carriage, medium, No. 1. W∧D I. R.C.D. 1886 Reg. No. A 621, Wt. 31 cwt.	—
		Platform, medium, No. 2. W∧D I. R.C.D. 1886 Reg. No. A 622, Wt. 50 cwt.	—
		Sir W. G. Armstrong & Co., Newcastle-upon-Tyne 9-in. 12-ton, R.M.L. gun, W∧D I. 1867 Reg. No. 407, Wt. 42¼ cwt.	Engraved on top of right hand bracket. On inscription plate. E.O.C. pattern and manufacture.
		Sir W. G. Armstrong & Co. Newcastle-upon-Tyne. 9-in. 12-ton, R.M.L. Gun. W∧D I. R.C.D. 1872 Reg. No. 805, Wt. 42¼ cwt.	Engraved on top of right hand bracket. On inscription plate. R.C.D. pattern E.O.C. manufacture.

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Nature.	Letter.	Examples.	Remarks.
Ordnance Mountings. — Iron or steel howitzer and mortar beds, and standing carriages.	B	No. 1. W∧D — R.C.D. Reg. No. B 325. 1886.	Stamped on rear axle bed.
		64-pr., 58 & 71 cwt. R.M.L. Guns. "depression." W∧D I. R.C.D. 1885 Reg. No. B 329, Wt. 28¼ cwt.	—
	C	12-pr. B. L. W∧D R.C.D. I. 1886 Reg. No. C 817.	Painted. Stamped.
		7-pr. 200 lbs. R.M.L. gun. W∧D I. R.C.D. 1886 Reg. No. C 544 Wt. — carriage ... 206 lbs.; wheels ... ... 144; Total ... 350	—
Iron or steel travelling carriages, siege, position, field, mountain, also limbers and wagons.		12-pr. B.L. Sir J. Whitworth & Co. W∧D 1887 Reg. No. C 1157 I.	Painted. Stamped.
		12-pr. B.L. Sir W. Armstrong, Mitchell & Co., limited. Newcastle-on-Tyne, No. 3955. 1887.	Painted. On plate. Stamped.

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Nature.	Letter.	Examples.	Remarks.
—	—	32-pr. 48 cwt. 1885. D 3618	—
Ordnance Mountings, wood, garrison, or travelling carriages, limbers, wagons, mortar—beds, &c.	D	Carriage, medium, No. 18, W∧D R.C.D., 1884. Reg. No. D 3284, Wt. 14½ cwt.	—
	—	Platform, medium, No. 15, W∧D R.C.D., 1884. Reg. No. D 3294, Wt., 18¾ cwt.	—
Transport Carriages. Iron, steel, or wood transport carriages, including carts, wagons, ambulance, R.E. and sling, also ammunition and store wagons.	E	Cart, water, IV. E 3872. R.C.D., 1885, W∧D	On plate. Stamped.
Miscellaneous. Iron, steel and metal,	S	Pack saddle, III. Reg. No. S 2071, Wt., 106 lbs.	A forge.
		Gyn, triangle, light, to lift 7 tons. W∧D R.C.D., II., 1887. Reg. No. S 6644.	On plate attached to pry-pole. Stamped.
Wood, leather, cork, canvas, &c.	T	12 — 86 T 46391 — No. 36 W∧D R.C.D., 1883 T 7548	A 12-pr. wheel. A box.

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Less important services than the foregoing, and articles liable to be easily detached from the services to which they belong, are marked in abbreviated form, so that they can be identified with the approved nomenclature.

EXAMPLES.

Approved Nomenclature.	*Stamping.*
Axles, roller, front carriage, garrison, wood, (iron with split key, also naval)	Car., wood, Slg. F.
Roller, carriage, No. 84, (metal, rear, naval, R.B.L., 40-pr., S.B. 32-pr.. 58 or 56 cwt., and medium, No. 18)	Car., rol., No. 84.
Heads, rammer, (R.M.L. 12·5-inch land service)..	R.M.L., 12·5-inch, L.S.

Articles made of	*Are marked*
Bronze, phosphor.	P. B.
Iron, malleable, cast.	M. C.
Steel, malleable cast.	S. M. C.
Steel, wrought.	S.
Steel, cast, tough.	C. S.

The system of using letters in conjunction with register numbers was introduced in August, 1883.

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RIVAL SHIELDS FOR GUNS IN LAND FORTRESSES,

FROM AUTHENTIC SOURCES, WITH RESPECT TO THE RESULTS OF THE BUCHAREST TRIALS OF 1885–1886, TOGETHER WITH THE BEARING OF THE KUMMERSDORF EXPERIMENTS OF 1885–1883 ON THE SAME QUESTION.

DRAWN UP BY

FRANZ KLOTZMANN, CHIEF OF THE ENGINEER STAFF.

Vienna, 1887.

A REVIEW.

BY

CAPTAIN C. ORDE BROWNE, LATE R.A.

THIS work, which is accompanied by an excellent series of plates, goes over the same ground which has already been traversed very fully in the "Proceedings" by the report of Major O'Callaghan and Captain Clarke. The Bucharest trials are dealt with in detail. The Mougin (French) and Schumann (German) turrets are compared as to their behaviour throughout, and the preceding series of experiments at Kummersdorf are noticed much more fully than in our English report.

Having already devoted so much space to this question, it is hardly desirable to do more than notice the conclusions arrived at by this author, however much it is to be regretted that work so fully and conscientiously executed should be passed over. French and German reviews and reports have long ago come to this country. They are naturally inclined to be prejudiced in favour of the system belonging to their respective fellow countrymen.

An Austrian writer may be supposed naturally to be less prejudiced. Klotzmann decides very strongly in favour of the German cupola. He gives various grounds for this; for example the fact that the Bavarian Major-General v. Sauer has strongly recommended the application of the Schumann system to permanent forts, and that the French turret itself has since been greatly modified and has now embodied in it the principal features of the German cupola. He gives on a large plate a central figure of the new French turret, and around it he places the various designs of Grüson in which the features of the French turret are seen already existing. Without question the form of the dome in the new French turret or cupola is exactly that of

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Schumann, and the carriage with its recoil press has nothing in it that is specially characteristic or that might not be found in carriages designed long since.

So much appears undeniable; but in other parts of his report it is more difficult to concur with the writer, whose tone contrasts badly as to accuracy and impartiality with our English report. In condemning the French automatic system of firing, he may be right. Certainly there is much to be urged in favour of a man-hole in the roof and other means of enabling the guns to be laid directly when desired. Although it is to be remembered, for our own information, that in our own coast batteries the Watkin designs for automatic firing are giving admirable results, there would be no cause for attributing prejudice to Klotzmann for a conclusion which appears to have been arrived at by most of those present at Bucharest. He goes on to very different ground however when he supports Schumann's statement that he can make two turrets for single guns for the same price as one Mougin turret containing two guns, and when he defends the muzzle pivoting in armour, of the guns of inferior power employed at Bucharest, without laying stress on the outrageous evils which accompanied this system, namely, the fact that when the two guns were not fired simultaneously the first one set up a rotation and oscillation in the turret that caused the second gun to throw quite wildly, and the fact that really powerful guns of the calibre employed would have knocked about the turret severely by their recoil.

Finally the statement is made in support of the value of certain trials that chilled-iron shot produce the same effect on chilled-iron structures as do the best steel projectiles, it is necessary to point out that the exact opposite is the fact—as is proved by the circumstance that Grüson has entirely altered the profile of his armour to meet the more formidable attack of steel projectiles, and that the increased effect of steel projectiles on Grüson armour which had hitherto been attacked only by chilled shot was such that, in France, Grüson armour, which had been contemplated for inland forts, was at once condemned for this purpose though still approved for coast defence.

On the whole Klotzmann's report is very valuable, but its value would have been enhanced had it been less prejudiced in its tone.

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REPLACING DISABLED HORSES IN A TEAM.

BY

LIEUT. G. E. BENSON, R.A.

In the March number of the R.A. Institution Journal there appeared a very interesting account of some experiments which Major Gambier, R.H.A., had been trying in order to be able to replace, quickly, disabled wheel horses in action without placing their harness on other horses. We have tried his plan thoroughly, and with a few modifications have found it thoroughly successful.

On trying Major Gambier's method with two guns, in which we placed the centre horses as wheelers, we found that it acted very well except for going down hill, where the rope breeching, cutting into the horse's quarters, caused one pair to kick and the other to gall; therefore we sought about for a way to remedy this. The method we finally adopted was this:—

Instead of the rope-breeching we took the breechings and cruppers complete off the disabled wheelers and placed them bodily on the centre horses. It will be remembered that in order to do this it is only necessary to unbuckle the crupper in rear of the cantle and the breeching at the loops on the shafts and the near side of the riding horse, making three buckles in all to be undone for each horse. It must always be possible to get at the buckle of the crupper and *one* end of the breeching, and since the other end is attached to the shaft and not to the horse, it can be disengaged by running back the limber. In disengaging a disabled horse quickly it is the traces and belly-bands that may have to be cut and not the breeching. Therefore in nearly every case it may be assumed that the breechings and cruppers can be got off complete at the same time as a fallen horse is being disengaged from the shafts.

The following is the drill I have written out for it, which after a very little practice can be carried out in four minutes. The gun is supposed to be in action:—

On the word "Wheel horses disabled," the drivers dismount and unhook. Nos. 6, 7 and 8 of the gun detachment assist, No. 6 the centre, and Nos. 7 and 8 the wheel driver. The remaining numbers continue serving the gun. The centre driver unbuckles his cruppers and loin straps and lays them aside. The wheel driver assisted by No. 6 unbuckles the cruppers and breechings (at the loops only) and No. 6 takes them complete to the centre horses and buckles them on, assisted by the centre driver. Meanwhile Nos. 7 and 8 hook a drag-rope in itself and stretch it out bringing the hook about the centre. They

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then make a loop in each end by tying double bowline knots, making the loops about the size of an ordinary tug. This makes a backband of exactly the right length. No. 7 places a blanket over the pad of the off centre (to prevent the hook scratching the leather) and No. 8 lays the improvised backband over it. The horses are then hooked in, No. 7 and 8 securing the traces by taking three turns round the splinter-bar with the outer traces and securing the inner traces by taking them round the shaft underneath the footboard and bringing them forward and hooking them in the trace loops. (In 13-pr. limbers there is no room to pass the inner traces round the splinter-bar). No. 6 takes another drag-rope and improvises a bellyband with it.

The pole draught proposed by Major Gambier we also find excellent; but there, again, a modification is necessary, as the shaft is not long enough to act thoroughly as a pole with big English horses, and the result is that when they try to stop the carriage their quarters come up against the splinter-bar before they can take the strain of the chain with their collars. To obviate this we find it best to leave the breeching acting on the riding horse as before, while the off-side of the breeching of the off-horse is buckled through a loop formed by hooking *both* ends of a short trace on the off hame-hook or links. By this means the horses go into their breeching almost immediately they back, and stop the carriage most effectually.

We find it unnecessary with most horses to connect the pair with a second head-collar chain to their head-collars.

On the word "Off-shaft disabled," the off-horse is unhooked and the shaft withdrawn, a spare washer of course being put on the axle-tree arm. The near-shaft is held up and the off-wheeler hooked in again, leaving the shaft through the near tug. Meanwhile one number passes a head-collar chain through the off hame loop of the riding horse, makes a clove-hitch on the shaft near the end, then passes the chain through the near hame loop of the off-horse and back again, bringing the shaft as high up as possible and making use of the spare end of the chain to strengthen the connection. Another number takes a short trace and fastens the off-breeching as before described. The whole thing can be done in little over two minutes. Of course if the near-shaft is disabled the off-shaft must take its place.

Both the above plans have been thoroughly tried by us at drill and over miles of hilly road, and found quite satisfactory.

IPSWICH,
8th August, 1887.

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PHOTOGRAPHIC "INSTANTANEOUS SHUTTERS."

BY

LIEUTENANT E. T. DIXON, R.H.A.

I. The ordinary "instantaneous shutter" is made on very unscientific principles. The object in designing a shutter should be to obtain the maximum light-effect in the shortest time. One obvious defect in the ordinary shutter is the shape of the hole; very little consideration will show that it should not be round (*i.e. concave* at top and bottom,) but *convex*; for the distortion of the image of a moving object continues, more or less, as long as *any* part of the aperture is open, it must therefore be economical to leave as much as possible open until the last moment. The edge of the hole[1] should therefore have a *convexity* equal to that of the aperture. Further, the slide or disc of the shutter should be moving at its maximum velocity before the exposure is made. This justifies me in assuming the velocity during exposure to be constant. It makes no difference in the calculations below, whether the shutter slides or rotates about a pivot. In the latter case the motion of the slide must be measured in inches round the arc described by the centre of the hole.

In photographing moving objects the *clearness* of the picture depends on the width of the blurr *on the negative*; but the *accuracy* depends only on the *real* width, which this represents, and is therefore independent of the distance of camera from the object, and of the focal length of the camera.

Granting these postulates, the following calculations be taken as accurate;—

II. *Calculation of exposure, and its effect on the plate.*

Let,—

T be the total time during which any light enters the camera.

E the amount of effect on the plate.

[1] In this paper "hole" means the hole in the slide; "aperture" the aperture of the diaphragm of the lens (both measured in inches) *vide* sketch.

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W the relative value of the exposure, so that, if f is the focal distance and k a constant depending on the brightness of the day, the subject, &c., &c.,—

$$E = \frac{k \times W}{f}$$

v the velocity of the shutter in inches per second.

a the diameter of the "hole" in inches.

b the diameter of the aperture in inches.

d distance of camera from the object.

t_1 the time (in seconds) taken by the shutter to travel the distance a.

t_2 " " " " " " b.

v the velocity of moving object (inches—secs.).

α the ratio of size of picture to subject.

β the amount of blurr admissible in the negative.

δ the distance the object may move during the exposure.

Then we have,—

$$a = vt_1, \text{ or } t_1 = \frac{a}{v} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(i)}$$

$$b = vt_2 \qquad t_2 = \frac{b}{v} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(ii)}$$

The time of exposure is made up of three periods;—1st, while the aperture is opening; 2nd, while it remains open; and, 3rd, while it is closing.

1st and 3rd periods are each equal to t_2, but the *average* amount of light entering is only half what it is during the 2nd period, which is equal to $(t_1 - t_2)$.

Hence the total time of exposure

$$T = t_1 + t_2 = \frac{1}{v}(a + b) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(iii)}$$

And by choosing a suitable unit, remembering that the value varies as b^2,

$$W = (t_1 - t_2)\, b^2 + 2b^2 \frac{t_2}{2}$$

$$= t_1 b^2$$

or

$$W = \frac{ab^2}{v} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(iv)}$$

III. *Problem.* If total *time* of exposure is fixed, when is its value a maximum?

We have above (iii.)

$$T = \frac{a + b}{v} \quad \therefore a = vT - b.$$

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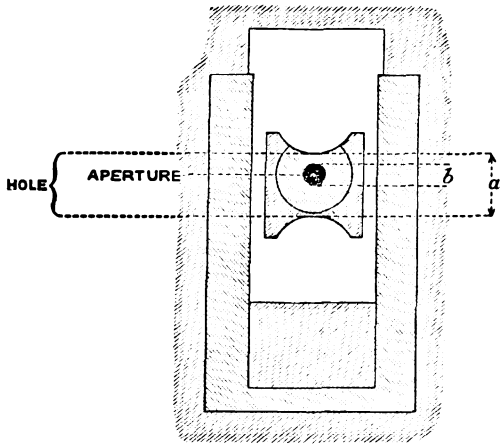
Substituting in (iv) we get

$$W = \frac{ab^2}{v} = \frac{b^2}{v}(vT - b)$$

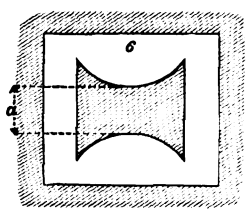
$$= Tb^2 - \frac{b^3}{v} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(v)}$$

Differentiate with respect to b,—

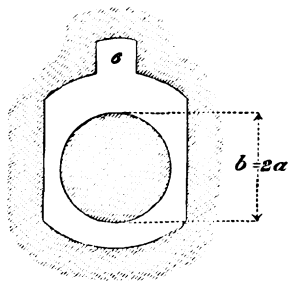
$$\frac{dW}{db} = 2Tb - 3\frac{b^2}{v} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(vi)}$$



SKETCH OF SHUTTER.



Theoretical Shutter.



Lens Diaphragm.

Again,—

$$\frac{d^2W}{db^2} = 2T - 6\frac{b}{v} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(vii)}$$

For a maximum we must have $\frac{dW}{db} = 0$,

$\therefore$ from (vi) we get, either, $b = 0$, or

$$2Tb - 3\frac{b^2}{v} = 0,$$

$$b = \frac{2}{3}Tv \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(viii)}$$

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Substituting this in (vii), the former value gives $\frac{d^2V}{db^2} = 2T$, which is positive, and therefore corresponds to a minimum. The latter value (viii) gives $\frac{d^2W}{db^2} = 2T - 6.\ \frac{2}{3}T = -2T$; and is therefore the value corresponding to the maximum.

Putting $\frac{a+b}{v}$ for T in (viii), we get,

$$b = \frac{2}{3}(a + b)$$

or

$$b = 2a.$$

That is, the aperture of the diaphragm should be double the hole in the shutter, to get the maximum effect.

IV. *Corolloraries to the above.*

1. From formulæ (iii.) and (iv.) we see that by diminishing the hole you lessen the effect of the exposure more rapidly than the time, unless the aperture is comparatively small, and may be neglected. Similarly by diminishing the aperture, you lessen the effect very much more rapidly than the time, even if the hole is so small as to be negligible in comparison with the aperture.

2. If you keep the hole and aperture always equal (and similarly if in a constant ratio)

$$T = 2t_1 = 2t_2 \text{ and } W = \frac{a^3}{v} = \frac{b^3}{v}$$

$$= \frac{2a}{v}$$

the time of exposure varies as the aperture, and inversely as the velocity of the slide. The value of exposure varies as the cube of the aperture, and inversely as the velocity of the slide.

3. When using a slide constructed to give maximum effect by (viii.) we have, substituting in (iii.) and (iv.)

$$a = \frac{1}{3}Tv \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \quad (a)$$

$$b = \frac{2}{3}Tv \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \quad (b)$$

$$W = \frac{4a^3}{v} = \frac{4}{27}T^3v^2 \quad \ldots \ldots \ldots \ldots \ldots \quad (c)$$

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4. From the above it appears that the maximum effect

$$E = k' \frac{T^3 r^2}{f} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (d)$$

That is, it varies directly as the cube of the time (or inversely as the cube of the velocity of the object photographed), directly as the square of velocity of the slide, and inversely as the focal distance.

5. The distance moved by the object during the exposure,

$$\delta = \frac{\beta d}{f} \text{ and, hence, } T = \frac{\beta d}{fV} = \frac{\delta}{V}. \quad \text{Also, } a = \frac{f}{d}.$$

Substituting in (d) we get $$E = \frac{k' \beta^3 d^3 r^2}{f^4 V^3} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (e)$$

or $$\beta = \frac{V f^{\frac{4}{3}} E^{\frac{1}{3}}}{d r^{\frac{2}{3}} k'^{\frac{1}{3}}} = \frac{a V f^{\frac{1}{3}} E^{\frac{1}{3}}}{r^{\frac{2}{3}} k'^{\frac{1}{3}}} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (f)$$

$$\delta = \frac{V f^{\frac{4}{3}} E^{\frac{1}{3}}}{r^{\frac{2}{3}} k'^{\frac{1}{3}}} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (g)$$

V. *Examples of the above.*

1. Required to photograph the *altitude* of a galloping horse. The fastest moving point will be the horse's feet, while he is throwing them forward. These may move double his pace. Suppose he is moving 14 miles per hour, we must allow for points moving 28 miles per hour.

= 14 yards per sec. = 42 feet = 504 inches per sec. (approx.)

As only the altitude of the horse is required, his feet may move, say, one foot during the exposure *i.e.* the whole time of exposure,

$$T = \frac{1}{42} \text{ sec.}$$

Suppose the velocity of the slide to be 80 inches per second (which is about that of my own). Then

$$v = 80,$$

$$\therefore a = \frac{80}{3 \times 42} = \cdot 636'', \quad b = 2a = 1 \cdot 273'', \quad W = \frac{4a^3}{v} = \cdot 013$$

(of the value of the exposure of one second, with a one-inch diaphragm). My largest stop is about 1·3″ and on a bright day (in India) I can get a fair picture with this value of W. This shows me that I have been in the habit of using much too large a hole in my slide, compensating by using a small stop.

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2. Required a *picture* of the same horse. If a picture is required the movement of no part should exceed an inch, say, and we get

$$a' = \frac{a}{12} = \cdot 053,$$

$$b' = \frac{b}{12} = \cdot 106,$$

$$W' = \frac{W}{12^3} = \cdot 0000074.$$

3. Is it then impossible to make a good picture of a galloping horse?

Consider formula (d); $E = k' \frac{T^3 v^2}{f}$,

k depends on the brightness of the light, and colour of horse, background, etc. It might perhaps be increased artificially. By using a small camera f can be diminished, and if the horse is to be far off, the maximum movement may be also. Probably a photograph might be made on a quarter-plate with

$$W = \cdot 01, \text{ and } T = \frac{1}{252} = \cdot 003968.$$

Substituting in (c); $W = \frac{4}{27} T^3 v^2$—we get,—

$$v^2 = \frac{27 \times \cdot 01 \times (262)^3}{4}$$

$v = 1039 \cdot 3$ inches a second.

A velocity of over a thousand inches a second would be hard to get, but if attainable,

$$\left.\begin{array}{l} a = 1 \cdot 375'' \\ b = 2 \cdot 75'' \end{array}\right\} \text{would not be impossible.}$$

VI. *Problem.* If the maximum velocity of slide, and value of exposure, are fixed; how to get the minimum time of exposure?

By (iv) $a = \frac{Wv}{b^2}$. Substituting in (iii), $T = \frac{W}{b^2} + \frac{b}{v}$

Differentiating $\frac{dT}{db} = \frac{1}{v} - \frac{2W}{b^3}$; $\frac{d^2T}{ab^2} = + \frac{6W}{b^4}$

Equating this to zero $b^3 = 2vW$,

But by (iv) $vW = ab^2$, and $\frac{d^2T}{db^2}$ is positive, $\therefore$ we get a minimum.

$\therefore$ $b^3 = 2ab^2$

$b = 2a$, the same condition as before.

VII. *General Deductions.*

From the formulæ (f) and (g) we see that the *clearness* of the photograph, taken under the most favorable conditions, using the same

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lens, varies inversely as the velocity of the object and directly as its distance from the camera; and the *accuracy* varies inversely as the velocity of the object and is independent of the distance from the camera.

When about to take an instantaneous view, the first thing to do is to determine the greatest movement of the object or its image which is admissible (δ or β). Then as you know E (depending on the sensitiveness of the plate) and k' (depending on light, subject, etc.) by experience, you will have to adjust f, d, and v so as to suit conditions (f) and (g). That is to say, the focal distance of your camera will vary as the square of the velocity you can obtain for your slide, if *accuracy* is desired, but if you only require *clearness*, it may also vary as the relative size of the picture required. Thus it is better to use a camera of short focal distance, close to the object than a long focal distance lens far off (in the ratio of $f^{\frac{1}{3}}$).

It will be seen that success in instantaneous photography does not depend so much on powerful lenses as on rapidly moving shutters. In Example 3 a lens of $2\frac{3}{4}''$ aperture is enough, but we must have a shutter sliding at 1039 inches per second. The condition $b = 2a$ is not observed in any shutter I have seen. On the contrary, a is double or many more times b. My camera works well with a 1-inch aperture. With a $\frac{1}{2}$-inch hole, maximum power of spring ($v = 80$) we get

$$W = \cdot 05, \qquad T = 0375,$$

quite enough to photograph a horse walking in bright light. In *brilliant* sunlight one might photograph a horse trotting, though the feet would be rather blurred if caught at the moment he was throwing them forward. The best camera for instantaneous photography has a wide-angle lens, of short focal distance. This enables a considerable size of plate to be exposed to the maximum amount of light. The shutter should move as rapidly as possible, and be provided with a set of diaphragms, having holes constructed with convex ends, to fulfill the condition $b = 2a$, with respect to the corresponding diaphragms of the lens. A duplex shutter might be tried. Thus, a large disc containing the "hole" is made to revolve at a high speed in front of the lens. Behind this is a second disc or *slide* with a round hole, so arranged that, on touching a key (during the revolution of the large disc), the slide is allowed to slip so as to open the lens *just after* the passage of the hole in the disc; and remain open until the hole has passed once more and then slip down. This could easily be arranged by spring catches actuated by a projection on the disc. Suppose the slide capable of opening and closing in one-tenth second. The period of revolution of the disc must not exceed this, but its 'v' being measured in inches round the arc described by the hole may be any quantity. To suit example (3) it must be 103·9 inches; diameter of disc must be 33·1 inches where the hole revolves, or about 3 feet over all. It would revolve 10 times a second.

MURREE,
June 4th 1887.

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TEXT-BOOK OF GUNNERY, 1887.

BY

MAJOR G. MACKINLAY, R.A.

A REVIEW:

BY

LIEUT.-COLONEL E. KENSINGTON, R.A.

THIS Text-book has been placed in our hands by the Committee of the R.A. Institution with the request that we would write a review of it for the "*Proceedings.*"

The previous works on Gunnery written by Officers of the Royal Artillery have been—

Boxer's Treatise (unfinished).

Owen's Gunnery.

Sladen's Principles of Gunnery, in which were first compiled the calculation of trajectories and the relations between distance, loss of velocity and time, for which we are indebted to the labours of Professor Bashforth. Colonel Sladen, being himself a mathematician, made it apparent in this work how dependent Artillery science is upon mathematical knowledge and skill. If only such an apparently simple question is propounded as to find the slope of the grooves at different positions in the bore of a gun with increasing twist, we find that Conic Sections and the Differential Calculus have to be employed. Indeed, it appears to us a matter for wonder that the Differential Calculus should be looked on with such awe in our Service, or why we should be content to be so far behind Artillery Officers of other nations in this respect. Even in America, where there is not the constant prospect of coming into collision with highly trained armies, every graduate from West Point into the United States Army is proficient in the Differential Calculus.

When Sladen's Principles of Gunnery went out of print, Major Mackinlay published, in 1883, his first Text-Book of Gunnery. This extended over a larger range of subjects and, though necessarily containing much of the information given in its predecessor, was a distinctly new work. It was adopted as the official book on Gunnery for the Land Service, and not merely for the use of cadets of the Royal Military Academy, as shown by the fact that the edition of 1400 copies ran out in 3 years, while only 427 copies were issued to the cadets. This Text-Book and a paper on "Steel" by Major Mackinlay (now

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revised and incorporated in the work, *see* Chap. IV.) are repeatedly quoted in the Manual of Gunnery for H. M. Fleet, 1886. The paper on "Steel" has attracted notice abroad, and has been copied into the Italian "*Revista Marittima*," and the U. S. official "Ordnance Notes." The Text-book is also freely quoted in the "External Ballistics" of Captain Ingalls, U. S. Artillery, and various other books and papers. In our Regiment, however, we have regretted to perceive much criticism on the ground that it was above the general reader (*i.e.*, amongst Artillery Officers) and contained too much mathematics. I will note one criticism by an officer who was particularly able to judge of the suitability of the work to the Corps at large. He objected to the correct mathematical definition of "energy" being given, and claimed that the "energy of a projectile" only should be defined. We consider that sound knowledge as distinguished from cramming can only be based on a proper understanding of universal principles, whence the application to the case in point should be easy. We uphold Major Mackinlay in his endeavour to give their correct general significance to all technical terms employed.

The present edition of 1887 was undertaken as an authorised Text-Book at the request of a Committee under the Director of Artillery Studies (Colonel Markham, R.A., now Dep.-Adjt.-Gen.) The general scope was considered and sanctioned by them, and the condition imposed that the more mathematical portions should be separated from the body of the work. This is the reason why there are two parts; Part II. not being consecutive to Part I., but containing additional matter belonging to Chapters II., V., XII., XIII., XIV. of Part I.

This edition is nearly double the size of the former one, containing 342 pages instead of 192, while its price has been lowered from 5s. to 4s. It bears evidences of much care and industry having been expended upon it.

It will probably be more satisfactory to our readers if, instead of a discursive review of the book as a whole, we take each chapter *seriatim* and draw attention to whatever appears most noteworthy in it.

CHAPTER I.—*On Definitions and Units* is now placed more suitably at the beginning instead of at the end of the book. Besides the technical terms used in gunnery, there are included definitions of physical expressions which are much used and have been very generally misused in artillery works. This is a praiseworthy attempt to lay down once for all, for the guidance of future writers on artillery, the precise meanings given to these words by mathematicians. There is often a tendency to confuse *force* with *work*, *stress* with *strain*, or generally *the cause* with *its effect*. It may be objected that the definitions here given require, in some instances, further explanation to make them intelligible to the ordinary reader; for instance, the *gravitation unit of force* brought into prominence by Professor Clerk Maxwell; also the definition of stress as the "action of balancing forces"; but doubtless Major Mackinlay prefers to leave such explanations to the instructors who use his Text-Book, and considers, we think advisedly, that a few

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correct words are more likely to be useful than voluminous explanations, which might even then fail to meet the difficulties experienced by all classes of minds.

A couple of pages are devoted to explaining *work* and *energy*.

There is a clear statement of the occasions on which, according to custom, the different units are employed. It is a cause for regret that there should be so little uniformity in the use of units but that yards should be used for one measure, feet for another, inches for another, leading to many errors on the part of all but the most careful.

For instance, the number of rotations of a projectile per second is given at p. 129 as $\frac{12V}{nd}$ because V is in feet, but d in inches, whereas on the same page we find linear velocity $= 2\pi \frac{Vr}{nd}$ where there is no multiplier (12) required, because v and d are both in inches, V is in feet, and the answer is required in feet. By italicising the words *inches*, *feet*, Major Mackinlay has done what he could to guard against error.

A list of the uses of different letters and symbols is given at the end of this chapter and much trouble has been taken throughout the work to adhere systematically to this arrangement. The same class of letter is used as far as possible for the same purpose, and in accordance with the usual mathematical practice. This may be summarized as follows :—

Small letters	*d*, *h*, *r*, *s*, *&c.*,	for lengths.
Earlier letters	*a*, *b*	,, co-efficients.
Middle letters	*m*, *n*,	,, abstract numbers.
Capitals	*A*,	,, areas.
Capitals	*D*, *E*, *J*, *P*,	,, angles.

Capitals opposed to small letters where larger and smaller quantities are used :—

E, *e* energies.
H, *h* height.
P, *p* pressures.
S, *s* distances.
T, *t* times.
U, *u*; *V*, *v* } velocities.
W, *w* weights.
Greek letters for angles.

CHAPTER II.—*Internal Ballistics.*—The experiment of Noble and Abel on fired gunpowder are repeated from the 1st Edition, also the description of the crusher-gauge. Different powders are compared by means of pressure, energy and velocity curves.

The very important subject of gravimetric density is thoroughly dealt with, also the use of Noble's Tables of Expansions. The practical importance of maintaining a uniform gravimetric density, that is, of always allotting the same space (no more and no less) to the same powder charge, is clearly shown by an incident (recorded on p. 25)

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that occurred when the projections on a Mark II. Lyon gas check prevented a 10-inch shell from being rammed home, and caused the range to be materially affected.

The examples (5 to 8) on this subject should be carefully studied.

This chapter is rightly placed at the commencement of the book as it is the very groundwork and foundation of all practical gunnery. Perfect guns and ammunition may be supplied, but their usefulness will be nullified in the hands of men who do not know how much depends on accuracy of loading. Quite lately we noticed a projectile rammed about 6 inches too far into the 111-ton gun. This may have caused the loss of about 10 foot-tons of energy for every pound of powder. True, the projectile was case, so the exact muzzle velocity was not of so much consequence, and it would presumably not happen with other projectiles, but every Officer of Artillery should be firmly impressed with the extreme importance of paying attention to the uniformity of ramming home.

CHAPTER III.—*Comparison of Guns.*—A useful addition is made at the end of this chapter showing the direction in which the improvements in gun manufacture have tended. We do not think however that it has been made sufficiently plain, in the course of the allusion to air-spacing, that air-spacing in itself is a distinct disadvantage, as it diminishes the muzzle velocity, but that a *combination of air-spacing with increased charges* gave increased velocities with diminished pressures in the chamber. This was a manifest improvement, though it is now superseded by slow burning powders.

CHAPTER IV.—*Steel.*—This is a new and interesting chapter on steel, being the substance of a lecture given by Major Mackinlay at this Institution in 1884. He explains very clearly how different the modern mild steels are from the steels of former days, and he treats of its employment for,—

13-pr. axletrees.
Rails and racers.
Wire.
Forgings of cast-steel for ordnance.
Plates and axles for gun carriages.
Shrapnel and common shell.
Nordenfelt bullets from steel bars.
Compound armour on both Ellis's and Wilson's plans.
Castings for marine engines.

The various tests are also given, and there are many illustrations.

CHAPTER V.—*On Gun Construction*—is much enlarged, and has many diagrams explanatory of the principle of shrinkage, by means of which the strength of the exterior portion is brought to the aid of the interior parts which are exposed to greater stresses. A simple experiment with a strip of cardboard and an india-rubber ring is described on p. 63, for showing the effect of shrinking. The principles are

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illustrated on the one hand (p. 68) by wire guns, where each layer is laid on with a tension calculated to contribute a maximum of strength with a minimum of material; and, on the other hand (p. 70) by cast-iron guns, where it is shown that the distribution of strength is exactly opposite to that which is theoretically correct, hence their weakness, and the inappropriateness of great thicknesses of cast-iron for ordnance.

On p. 72 is shown the application to new type ordnance of a most important principle, namely—that, in built-up ordnance, the same pieces should not be exposed to a diversity of strains. Since the A tube must receive the brunt of the circumferential stresses, it must be relieved from all longitudinal strain, if possible; as is effected in the later patterns, namely, in the split ring, and Colonel Maitland's constructions.

These constructions do not appear to be mentioned in the following chapter, where we should expect to find them.

CHAPTER VI.—*Details of Gun Construction.*—The section on twist, scarcely altered from the first edition, deserves notice. It treats of the comparative merit of uniform and increasing twist on which many Artillery Officers are still disagreed. The argument against increasing twist is that, as the velocity increases, so the rotation increases gradually even with uniform twist; why then should we not be content with it? The reply is that the increase is not sufficiently gradual at the commencement, as shown by the pressures on the studs calculated by Col. Maitland's formula (*see* Table, p. 77). Here the pressure on the grooves near the commencement is shown to be nearly twice as much with uniform as with increasing twist at its maximum. The diagram on p. 78 illustrates this.

CHAPTER VII.—*Laying.*—A very clear description, with diagrams, of Scott's sights has been added to this chapter, showing plainly how the effect of any inclination of the trunnions is eliminated, and how no fore-sight is required when using the telescopic sight. Now that Scott's sights have been adopted into the service, this brief explanation will be found useful and interesting. The rest of the chapter gives the usual rules and formulæ for laying, including that for the *permanent angle of deflection*, the correction for inclination of the trunnions, the principles of reflecting sights and cross-bar sights, also of position-finding. The question of laying at a moving object is considered at some length.

CHAPTER VIII.—*Recoil.*—This is much the same as the corresponding chapter in the former edition, but it has been re-written and improved. On p. 102 a paragraph is introduced to distinguish between the jump of the gun relatively to the carriage, and the jump of the gun and carriage together. The former has to be met by a judicious construction of the carriage: both tend to increase the angle of departure. This subject which is here treated briefly, but clearly,

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marks how close is the connection between the duties of the Artilleryman and a knowledge of construction. He may not be called on to manufacture military stores, but the more knowledge he has of their construction and of the reasons on which this construction is based, the better is he able to apply them to an intelligent use. There is no telling when he may not be required to extemporise some repair or makeshift. Also the suggestions of properly qualified officers on service are invaluable to those who are responsible for manufacture.

In the former book two formulæ were given for approximately calculating the velocity of recoil, both necessarily based on the principle that momentum of recoil equals momentum of charge; but since the weight of the powder has of late years been so largely increased in proportion to the projectile, it is difficult to say what is the momentum of the charge. It certainly exceeds that of the projectile alone.

The first formula (repeated as No. ii. in this edition) takes the muzzle velocity with a certain mean weight of charge, namely, the projectile and part of the cartridge, the remainder of the cartridge been left unconsidered.

The second formula (Mr. Butter's, omitted now) took the whole charge with a mean velocity estimated at three-fourths the muzzle velocity. Some critics have pronounced this formula to be irrational, but on what grounds we fail to perceive.

A new formula is now introduced (No. i.) which treats half the cartridge as remaining solid and moving with the gun, while the other half has a mean velocity equal to that of the projectile. This supposition is fairly consistent with the experiments on fired gunpowder, *see* page 20, where the solid residue is given as rather more than half (·57) of the whole.

The chapter concludes with the various methods of controlling or utilising the force of recoil.

CHAPTER IX.—*On Atmospheric effect*—treats of the effects of the blast, velocity of sound of firing, visibility of projectiles in flight, advantages and disadvantages of smoke, fouling and heating.

CHAPTER X.—*On Muzzle Velocity*—explains the various contrivances for estimating the velocities of projectiles. New drawings are given of the improved Boulangé chronograph, and the various contrivances introduced by Captain Holden, R.A., Proof Master, Royal Arsenal. It will be remembered that this chronograph consists mainly of,—

(1) A "chronometer" rod with zinc casing which falls as the projectile passes through the 1st screen.

(2.) A "registrar" rod which falls as the second screen is pierced, and releases a cutter which makes a nick on the chronometer.

The distance fallen by the chronometer includes a portion corresponding to a constant time ·15 sec., (occupied by the fall and action of the registrar), and is measured by a scale. This scale is graduated not only in inches but also in velocities calculated for a fixed distance between the screens.

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CHAPTER XI.—*Twist and Drift.*—Uniform and increasing twist are explained, and the combination of them used for our new type B.L. guns. Also the peculiar twist of the 16-inch R.M.L. of 80 tons is mentioned.

On p. 129, the formula for angular velocity is put in a more convenient form than hitherto, namely $2\pi \frac{12V}{nd}$ where $\frac{12V}{nd}$ is the number of revolutions per second.

The old explanation of cushioning is revived on p. 135 as one of many possible explanations of drift, and sound reasons are urged for its consideration, in combination with the gyratory theory explained more fully on p. 243 in Part II. We are cautioned that "in the present state of our knowledge it is impossible to give reasons for drift which will be received by all, as different explanations have been given by various authorities." We agree with Major Mackinlay that drift is "a differential effect, due to several causes." The chapter concludes with a practical summary of "facts connected with drift." These facts are established, whatever may be the opinions as to the causes.

There is not much said about the amount of rotation required to keep the projectile straight, but a few elementary principles are laid down, as well as the formula for calculating the energy of rotation from given conditions. There is however in Table III., on "Stability of Rotation of Projectiles," a reference to Professor Greenhill's formula, by means of which the calculations are made. This Table furnishes all the information that appears necessary for a practical knowledge of the subject.

CHAPTER XII.—*Resistance of the Air.*—In this chapter is explained the ordinary formula $R = d^2\sigma\tau \frac{K}{g}\left(\frac{v}{1000}\right)^3$ for calculating the resistance of the air, with the meaning of and reasons for the different factors involved.

We doubt however if the reason for the factor $\frac{1}{g}$ will be plain to those who have not studied the question of units. The words employed are "the constant g appears in order to reduce absolute to ordinary gravitation units," and there is a footnote which defines "The absolute unit of force, called the poundal, is that which acting for one second on one pound generates a velocity of one foot per second; the gravitation unit of force contains g poundals."

The formula $W = mg$ must be familiar to all. This means that a weight W (or 1 pound) acting vertically in vacuo on its own mass for one second will generate a velocity of 32·2 (or g) feet per second. Then a weight $\frac{1 \text{ lb.}}{g}$ acting on the mass of 1 lb., will generate a velocity of one foot per second. This weight is called a poundal.

Thus 1 lb. contains g poundals.

When using ordinary units we have $W = mg$.

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When using absolute units we have $W = m$, where W is the number of poundals.

After all, the insertion of g in the denominator only serves to prevent its remaining in the numerator of the formula for the retardation (No. iv. of p. 142).

So long as there is an unknown constant K we are at liberty to insert as many other constants as we please, such as $\frac{1}{g}$ and $(1000)^3$.

They merely affect the size of K which is to be found by experiment in conformity with the formula which is thenceforth fixed and unalterable.

Perhaps this may be illustrated by an example.

The weight of a sphere varies as the cube of its radius and the specific gravity of its material.

One man says that $W = kr^3s$.
Another says $W = c\pi r^3 s$
Another says $W = Kr^3s \times 1000$ ozs.

It is found by weighing a sphere of iron ($s = 7{\cdot}8$) two feet in diameter, that its weight is $4188{\cdot}8 \times 7{\cdot}8$ oz. (r being 1).

$$\therefore k = 4{\cdot}188{\cdot}8 = (\text{we observe}) \frac{4}{3}\pi \times 1000.$$

$$c\pi = 4{\cdot}188{\cdot}8 \qquad \therefore \quad c = \frac{4}{3} \times 1000.$$

$$K \times 1000 = 4188{\cdot}8 \qquad \therefore \quad K = \frac{4}{3}\pi$$

Hence the result, the same for all,

$$W = \frac{4}{3}\pi r^3 s \times 1000 \text{ ozs.}$$

We have ventured to insert this explanation, not to remedy any deficiencies in the text, but to remove, if possible, certain doubts, that some readers might experience, as to whether the insertion of convenient constants were lawful.

The "co-efficient of reduction" $\sigma\tau$ has been introduced into the formula for resistance since the publication of Major Mackinlay's first edition. This, like the rest of the subject, is due to Professor Bashforth, and is intended to make his tables applicable to projectiles of various form, and to different atmospheric conditions, as tabulated in Table XI. These, like all other unknown constants, have had to be determined by experiment.

Values of K are given in Table IV.

The actual resistance of the air at different velocities, on a projectile of 1-inch diameter are given in Table V.

The very important Bashforth Tables, now called Ballistic Tables in conformity with foreign usage, together with a corrected abridgement by Professor Greenhill, are given in Tables VI. to X., and several explanatory examples are worked out in Chapter XII.

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The whole of the mathematical calculations, by means of which these tables have been obtained, are transferred from the body of the work to the end, out of deference to a very generally expressed desire that the calculus should not appear. They will be found in Chap. III. of Part II.

CHAPTER XIII.—*Trajectories.*—The previous chapter related only to flat trajectories, and did not take into estimation the height of the projectile in the course of its flight.

The present chapter commences with the more important formulæ of trajectories in vacuo, and proves therefrom Sladen's formula for the height of any point of a flat trajectory in air; $h = \frac{1}{2} gtt'$ in terms of the time from each end of the trajectory; the idea being that the vertical velocity of the projectile is so small that the resistance of the air in that direction may be neglected.

Formula vii. gives the maximum height (not at half the range, but at half the time). We do not approve of the reduction of $\frac{1}{2} g \left(\frac{T}{2}\right)^2$ (which explains itself) to $4T^2$, which is liable to be used blindly. Applications of Sladen's formula, together with the Ballistic Tables, to problems connected with the "dangerous distance" are worked out. Also an interesting comparison of the trajectories of three rifles is plotted: they are the Martini-Henry, Mauser and Enfield-Martini.

Another example estimates the effect on a target if the muzzle velocity be slightly altered, and another shows that the time of flight and consequently the range can be approximately estimated without range tables, when a low angle of elevation is given, provided the jump be added.

For trajectories with an angle of departure up to about 15°, Niven's abbreviated method is given as being more accurate than the foregoing, because it does not neglect the resistance of the air in a vertical direction. He connects the inclination of the trajectory with the velocity; his results are compiled in Table VIII.

The process may be put shortly as follows:—Given the angle of departure, M.V. and $\frac{d^2}{w}$ of projectile; the distance and height of the highest point, as well as the velocity there, are obtained.

Next, by a similar process, after assuming a probable angle of descent, the distance from the vertex to the point of impact is calculated, also the remaining velocity.

This method is an abbreviation of those given in Chap. IV. of Part II.; the first by Professor Bashforth, who calculated the whole trajectory by successive portions, by means of the horizontal and vertical distances for each, and the change of slope and of horizontal component of the velocity. This was continued to the vertex, and then downwards again till the total descent equalled the total ascent. This was succeeded by a less laborious method due to Professor Niven, who resolved his forces, horizontally and normally, instead of horizon-

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tally and vertically, and was able to take longer arcs by obtaining a mean value of the inclination for each arc. Professor Bashforth takes the slope of the trajectory as his independent variable. Professor Niven takes the horizontal component of the velocity.

An example of howitzer fire at 23° is worked out on p. 271 by Niven's method, and the results are shown to agree very closely with the published range tables, the slight difference being probably due to neglect of the jump.

The motion of rockets is alluded to at the end of the chapter.

CHAPTER XIV.—*Accuracy.*—We are unable to perceive why this chapter should have been introduced here before continuing the subject of trajectories to which the "angles of descent," treated in Chap. XV., would appear properly to belong. We prefer the arrangement of the first edition in this respect.

The chapter on "Accuracy of Fire" is one of the most important in the book, and is well worthy of study. The chief causes of inaccuracy are classified as due to the gun, the ammunition, errors in laying, wind. To these might be added the very important causes of inaccuracy mentioned on p. 25 and p. 184, namely irregularity in ramming home. We should recommend therefore the words "and drill" to be added to "errors in laying" on pp. 169 and 170.

The method (based on strictly mathematical principles shown in Part II., pp. 274 to 276) of estimating the 50 per cent. zones is explained very clearly on p. 170, &c., and these zones appear to us to be for the first time correctly designated.

"Breadth zone"	depending on	lateral errors.
"Length zone"	"	longitudinal errors.
"Height zone"	"	vertical errors on target.

This being a subject that often presents difficulties Major Mackinlay has taken especial pains to remove them by means of diagrams and careful wording followed by interesting examples.

The method of obtaining the figure of merit of ammunition for small-arms is explained and illustrated by a reduced copy of one of the Royal Laboratory diagrams. It should be noted that the result is entirely independent of the distance of the hits from the point aimed at. The figure of merit marks the uniformity of the shooting, not the correctness of the sighting.

With reference to "Accuracy on Service" treated on p. 179, we should again add "and drill" to "errors in laying" and would draw attention to the German squad who are mentioned on p. 180 as having doubled their accuracy after being well instructed.

The description of Morris tubes with diagrams is a useful addition.

The few remarks on range-finders will probably be found somewhat unsatisfactory, as being more suited to a popular review than to a text-book, but doubtless Major Mackinlay felt that if he attempted to give any definite iustruction on this subject, he would be unable to draw

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the line between incompleteness on the one hand, and excessive detail on the other. The information is already given in the Handbooks.

The remarks on ricochet and shrapnel fire are good; they conclude with Commander May's empirical formula for the angle of dispersion of shrapnel fire.

CHAPTER XV.—*On Range Tables*—refers to Tables XIII. to XV., which are extracts from the range tables for a gun and for a howitzer. The following matters are specially considered :—

Ranges when firing up or down hill.
Practical determination of the "jump" of a piece.
Connection of range and elevation by means of a curve.
Correction of elevation by noting the error in the range and the number of yards given by each additional minute at that range.
Estimation of the angle of descent by the formula—

$$\tan \beta = \frac{R \tan \Delta\alpha}{\Delta R}.$$

No examples have been given to illustrate this; we therefore submit one—

Range Table XIV. gives 1° 38′ elevation for 2000 yards range.
1° 32′ „ 1900 „
1° 44′ „ 2100 „

shewing that each minute gives about $\frac{100}{6}$ yards.

$$\therefore \tan \beta = \frac{2000 \tan 1'}{\frac{100}{6}} = 120 \times \frac{\pi}{180 \times 60} = \frac{1}{90} \times \frac{22}{7} = \frac{11}{315} = \frac{1}{29}$$

∴ slope of descent is one in 29, which agrees with the 4th column of the Table.

If instead of $\frac{\pi}{180 \times 60}$ we take the common approximation—

$$\tan 1' = \frac{1}{60 \times 60}$$

the result is nearly the same, *i.e.*, one in thirty.

Other methods of calculating the angle of descent are also given, but these have not the merit of depending solely on the information contained in the range tables.

The reader is reminded on p. 192 of the importance of curves for determining any required details, such as angles of descent after a few have been calculated; as shown on p. 189 for ranges. See also the diagrams on p. 194.

The irregular burning of fuzes with different projectiles is noted on p. 193. The conclusion we should arrive at is the direct opposite of the recommendation that fuzes should be graduated for ranges. The present practice of giving a fuze scale in the range tables would seem to be the best method of meeting the difficulty.

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Whilst dealing with howitzer fire on pp. 193 to 195, we would advocate the extension of its use to defending our seaports and coast towns from vessels of war, by high-angle fire with the aid of the position-finder; to facilitate which a suggestion has been made by Lieut. Cooper-Key, R.A., that howitzers should be fired from travelling carriages on rails, and that sidings should be constructed from the railways to convenient positions for commanding the anchorage. Thus the same war matèriel would be available for the defence of all places connected by rail.

CHAPTER XVI.—*On Armour*—explains the various constructions of armour defence; the difficulties connected with the bolting of plates together; steel plates; compound armour; Grüson's chilled armour for coast defence; practical applications in different forts and ships, with many diagrams.

CHAPTER XVII.—*Investigates the Penetration of Armour*—showing with the aid of diagrams how the projectile acts on the armour according to the material of each. Various empirical formulæ are given, depending upon the following principles:—

Penetration, measured in calibres, varies as the square root of the energy of the projectile.

Effect of similar projectiles of different calibres depends on the fraction $\frac{w}{d^3}$.

The best value of this fraction (using pounds and inches) was thought to be ·37 but is now preferred nearer ·5.

Colonel Maitland's formula and graphic diagram are given—thickness in calibres $= \frac{V}{608 \cdot 3}\sqrt{\frac{w}{d^3}} - \frac{\cdot 14}{d}$; also Captain Orde Browne's quick rule-of-thumb that each 1000 f.s. gives a penetration of one calibre through wrought-iron.

The rules for dealing with oblique penetration are given on p. 219, but not as clearly as we could wish; also there is a clerical error. There is no formula stated, but instructions are given to modify the elementary formula on p. 212 by the substitution of $\frac{v}{\sin\theta}$ for v, where θ is the angle made by the projectile with the face of the plate; that is to say, if a normal velocity v suffices to produce a certain penetration, the oblique velocity must be $\frac{v}{\sin\theta}$ in order to produce the same effect. The clerical error is that $\frac{v}{\sin\theta}$ is put for the normal velocity; this should be v; the final result is not affected.

CHAPTER XVIII.—*On Penetration of Earth and Masonry*—is mainly a summary of the results of the practice at Lydd. We cannot pass by

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without comment, the well-known fact that penetration in sand is ordinarily less than it is in earth or even clay, *see* p. 225. So far as we are aware no satisfactory reason has been assigned for this. Is it that the particles of sand, being angular, fit more closely together, so as to leave fewer interstices? Or is it that clay and other earths are more compressible being of less rigid formation than silica? Or that they are formed of particles so extremely fine that they yield, somewhat after the fashion of fluids?

This concludes Part I.

Part II. contains whatever is considered too difficult for the ordinary reader. It includes—

The ballistic pendulum and other instruments.

Determination of the twist of rifling at different distances along the bore.

The theory of the gyroscope.

The internal strains in thick cylinders.

The calculations by which the ballistic tables were formed.

Bashforth's investigation of the resistance of the air and calculations of trajectories.

Niven's method.

Calculations leading to the factor 1·69 (*see* p. 172) for determining the width of the 50 per cent. zones.

The Tables have been compiled most laboriously and carefully, and each is followed by explanations of its use. Besides those already mentioned in this Review, there are—

XVI., a list of service ordnance with full details of charge, projectile and ballistics.

XVII., a similar list of foreign ordnance.

XVIII., tables of weights and measures, both English and metric, with, it appears to us, too profuse explanations.

XIX., logarithms of numbers, sines, tangents and secants.

The book concludes with that very necessary addition—an Index.

In submitting these criticisms to the Members of the R.A. Institution we do not wish to set up our own opinions against those of Major Mackinlay in the few places where we have differed from him, nor do we claim that all others should agree where we are agreed, but we do invite them to read this Text-Book for themselves, and to use the information they find there to assist them in forming their own opinions. Let them remember that many works have to be studied before a book of this kind can be brought out, that the task is a thankless and profitless one, and that the author has no reward to look for, other than the approbation of his brother officers, and the advancement of Artillery Science.

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WAR SERVICES

OF

CERTAIN OFFICERS OF THE REGIMENT WHICH ARE NOT GIVEN IN KANE'S LIST AND OF CERTAIN OTHERS WHICH ARE ONLY IMPERFECTLY GIVEN.

COMMUNICATED BY

GENERAL SIR J. H. LEFROY, C.B., K.C.M.G., F.R.S., LL.D., R.A.

No. 9.

MAJOR-GENERAL THOMAS TROTTER,

Colonel Commandant, 5th Battalion, Royal Artillery.

ENTERED the Royal Artillery as Lieutenant Fireworker, January 10th, 1770. In 1773 he went to America, and in 1774 joined the Army in Boston, where he remained until the evacuation of that place in 1776. He accompanied Sir William Howes' Army to Halifax, and from thence to the neighbourhood of New York, and was present at the affairs of Brooklyn, White Plains, November 30th, 1776.

In 1777 he accompanied the Army up the Chesapeake to Philadelphia, and was present at the affair of Brandy Wine Creek, September 13th, 1777. He returned with the Army through New Jersey to New York in 1778, and in 1779 went to Virginia with the late General Leslie, and to Carolina. From 1779 to 1782 in various parts of America, but having been appointed a Captain-Lieutenant in October 1781, he returned to England in the summer of 1782.

In 1787 he went to Canada, and remained in that country until 1790, when he returned to England upon succeeding to a Company of Artillery in the month of March in that year, which Company was quartered at Portsmouth.

In 1793 he went with his Company to Flanders where he served with the Duke of York's Army, and returned with it to England in the summer of 1795. During the time of his being in Flanders he was present at the Siege of Valenciennes, and at several actions in the field, at one of which he had the honor to receive His Royal Highness the Commander-in-Chief's thanks in public orders; during the principal part of the campaigns in Flanders, he served as Brigade Major to the Artillery; he served with the Army in Holland during the short campaign of 1799. In 1801 he was ordered on duty to Ireland, where he remained.

He was appointed Colonel in the Artillery July 20th, 1804; Brigadier-General in the Army, April 1808, and Major-General, July 25th, 1810.

Major-General Trotter died in Dublin March 6th, 1819, having been above forty-nine years in the Corps.

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No. 10.

GENERAL SIR JOHN SMITH, G.C.H.,

Colonel Commandant of the Royal Horse Artillery.

BORN AT BRIGHTON, FEB. 22ND, 1754.

ENTERED the Royal Artillery as a Cadet, March 15th, 1768, and was promoted March 1st, 1771, to 2nd Lieutenant. In 1773 he went to Canada, and was present at St. Johns, where he was taken prisoner, 5th Nov., 1775. In Jan. 1777, he was exchanged and joined the army at Rhode Island, under the command of the then Earl Percy, and shortly after joined at New York, under the command of the then Sir Wm. Howe, he was in all the subsequent actions and sieges during the war, viz:—Brandy Wine Creek, Sept. 13th, 1777; German Town, Oct. 14th, 1777; Charleston, May 4th, 1780; York Town, Oct. 29th, 1781. When Lord Cornwallis surrendered, he returned to England, on parole, after a service of nine years in America.

In 1785 he went on command to Gibraltar, where he remained five years. In 1795 he was ordered to join the army under Lord Moira, at Southampton, as Major, to superintend the gunners and drivers on that service, and as second in command of the artillery, under General Stewart, for foreign service. In October in the same year he was ordered to the West Indies under the command of the late Sir Ralph Abercrombie, and became commanding officer of artillery and remained until 1797, when he was relieved in consequence of ill-health.

In 1799 he was ordered to join the expedition under H.R.H. the Duke of York, for Holland. In 1804 he was sent with the command of artillery to Gibraltar, where he remained ten years, till 1814, during which period the command of the fortress devolved on him. He was twice slightly wounded, and three times shipwrecked.

Sir John Smith had conferred on him the Grand Cross of the Guelphic order, and upon the death of Sir John McLeod succeeded him as Colonel Commandant of the Royal Horse Artillery, Jan. 27th, 1833. Promoted General, Jan. 10th, 1837.

He died at Charlton, July 3rd, 1837.

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METHOD

OF

CALCULATING TRAJECTORIES.

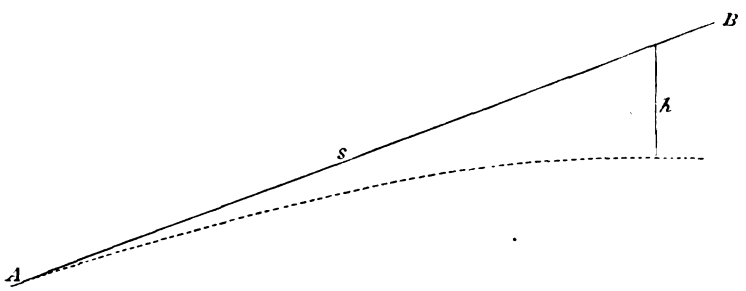
BY

CAPTAIN D. F. DOWNING, R.A.

THE idea pursued throughout the following investigations has been to obtain, from the experimental data furnished on the practice ground, a more direct and simple means of calculating the results of fire than is at present available.

In speaking of an "investigation" it is necessary to state distinctly that no pretence is made to a *mathematical* investigation in the usual meaning of the term; the investigation being purely one of facts observed in practice, which has been, and is, continually carried out at Shoeburyness for the determination of range tables. All the statements made must therefore be accepted as embodying as faithfully as possible the results of actual observation.

The method is based on the assumption that the Bashforth Tables give us the position of a projectile if gravity did not act, and that the true position will be found vertically beneath this at a depth depending on the vertical acceleration that may be due to gravity under the particular circumstances. This of course is nothing more than an extension of the principles recognised in vacuo, viz., that if a projectile starts from A towards B with a velocity v, its position at the end of a



given time t, will be found by measuring along $A\,B$, a distance $s = v\,t$, and from that point dropping a vertical $h = \frac{1}{2}\,g\,t^2$; but being applied to motion in air, the first value s is obtained by Bashforth's Tables,

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and the endeavour now has been to obtain the second value by reference to the facts observed in practice.[1]

The plan adopted has been to take from the records of firing the following data :—

Quadrant Angle of elevation ... $= a$
Mean range .. .. $= R$
Observed time of flight ... ... $= t$

then to deduce the height presumably fallen at the end of the range by

$$h = R \tan a$$

and then to try and obtain a law connecting h and t.

It soon became apparent that h varies so nearly as t^2—in all cases, howitzers and guns alike—that the equation

$$h = ft^2$$

was adopted in the expectation of obtaining f as a "variable constant."

The general results obtained are embodied in Table I. and its Appendix, which gives the average value of f for any particular gun or howitzer in terms of its (log) $\frac{d^2}{w}$ and *M.V.*, so far as has been ascertained—and a little further speculatively.

As a first general explanation of this Table it must be stated that it appears that for howitzers and light and medium guns (in fact, for all those natures not included between the black diagonals on the Table, and for which numerical values are given) this average value for f may be used unaltered at all ranges[2] and thus for a large number of pieces f may be treated as an *absolute constant.* But this is not the case with all the values given in the Table.

The others, so far as has been ascertained, still represent with truth the average values, but beyond a certain point it is no longer sufficiently true to consider f as constant, and the main difficulty lies in determining when it becomes necessary to treat the value of f as *continually diminishing* as the range increases. This condition of things appears to occur towards the right hand top corner of Table I., and generally when the log $\frac{d^2}{w}$ is less than $\bar{1}{\cdot}35$. The data for this portion of the Table, which refers to the heavier natures, are unfortunately meagre, so it is difficult to say anything about it confidently, but the Appendix to the Table gives a series of values for f (referred to t) which is apparently applicable to a large number of the heavy guns.

[1] It is satisfactory to learn that there is nothing novel in these ideas, removing, as it does, a great deal of diffidence in trying to found a system upon them. This very plan was adopted (at the suggestion of Col. Maitland, R.A.) for the computation of the range tables of the howitzers, &c., by the Committee on Siege Train Equipment, but was considered to "fail" on the appearance of a correction. The method was however practically employed, and very much the same conclusions drawn as have been arrived at here—it is not necessary to give these—but lest too much authority may be thought to be claimed, the present author takes the responsibility for any of the suggestions made. It is believed that the process of "correction," and indeed the Tables generally may be said to be new.

[2] Under 9 secs. in these cases the results are apt to be uncertain, owing probably to "jump."

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For the rest it appears that for any gun above the 6-inch, the early values given in the Appendix may always be used up to 9 secs., but for the longer ranges, *where the velocity is high*, instead of the mean value indicated in the Table, the values in the Appendix should be used, diminished by the amounts indicated by the mean. Three short (black) diagonals have been drawn to show where it is supposed that similar values will apply under these conditions, and these have been figured with the amounts to be subtracted from the appendix values.[1] The results of practice with the high velocity 9·2-inch wire gun will doubtless afford a good deal of information, and may confirm or refute the suppositions already formed. We have at present no piece represented in the right hand bottom or left top corners, and it is therefore impossible to say what takes place there.

Calculation of Time of Flight.

The next point to be considered is the calculation of the Time, and it is satisfactory to be able to state in connection with this, that there appears in general no necessity to tamper with the natural value of the $\frac{d^2}{w}$, indeed it seems desirable to take that information most readily available, viz., the calibre in preference to the diameter of the shell, &c., it is necessary however that the *actual* weight of projectile should be known, and before all things essential that the *M.V.* is tolerably correct. These points being observed the value of t may be obtained by the Bashforth Tables in the usual way by taking

$$s = 3\ R \sec \alpha$$

(R being as usual in yards) until the range becomes so great as to necessitate a correction, presumably for tenuity of the air due to the height of the trajectory. The limit to which the natural $\frac{d^2}{w}$ is available appears to be about 4000 yards for light and medium guns—direct fire; howitzers full charge 3000; reduced charges less, but the reduced charges do not carry much beyond their (correction) limit. This correction for height of trajectory appears at first the most difficult part of the whole subject, for it implies a knowledge to start with as to what the height of the trajectory will be, and this is about the last thing ascertained. Then supposing a law of correction to be ascertained, the question arises as to what are the most convenient terms in which to express it, this depends so largely upon what the nature of

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[1] The following example will illustrate what is meant by this. The 8-inch B.L. (IV.,) with $\log \frac{d^2}{w}$ = 1·484 and M. V. = 2150 comes on to the short diagonal numbered 1·1, and has a mean f = 12·78. If however this value is used throughout, the range curve is distorted; the more correct values at different times would be:—

At $t = 3$; $f = 15{\cdot}1$ Appendix. $t = 12$; $f = 13{\cdot}8 - 1{\cdot}1 = 12{\cdot}7$

$t = 7$; $f = 14{\cdot}26$ " $t = 30$; $f = 12{\cdot}74 - 1{\cdot}1 = 11{\cdot}64$

The same gun however with ¾ charge, when M. V. = 1812 does not come between the short diagonals, and the appendix values should be used up to 9 secs., after which the mean, viz., f = 13·34.

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the problem may be, which has to be solved. The correction, when necessary, is applied of course to the $\frac{d^2}{w}$, this being diminished as the height of trajectory increases. This function is among the very first employed, and hence the necessity for an early conclusion as to the correction.

All through, the process of calculating trajectories must necessarily partake of the nature of a series of trials, however direct we may endeavour to make it, the only thing to be done is to try and reduce the occasions on which it is necessary to go over the same ground twice. Take for example the first general problem in which it is desired to calculate the elevation required for a given range or *vice versâ*; here, if any correction is necessary it should obviously be given in terms of the range, and yet it seems hardly possible to effect this, since nearly every gun has a different maximum height of trajectory for the same range. We are helped however to a certain extent by the circumstance that when the law applicable to one gun ceases to be applicable to another, so does the range for this gun cease to be a "practicable" one.

Taking now a general view of Table I., it is evident in the first place that each of the values of f corresponds to a distinct character of trajectory, to determine which the conjunction of $\frac{d^2}{w}$ and M.V. has to be considered. Thus, the most curved trajectory is represented where the $\frac{d^2}{w}$ is greatest and the M.V. least, viz., in the left hand bottom corner; the flattest trajectory is when the $\frac{d^2}{w}$ is least, and the M.V. greatest—in the right hand top corner. We might expect therefore that there will be lines of *similar* trajectories running across this diagonal, and this appears to be actually the case. Searching for comparisons it appears, for instance, that the 3-pr. Hotchkiss has its prototype in the 8-inch R.M.L., and the 5-inch B.L. (II.), in the 12-inch R.M.L. (I.), while the trajectory of the 2·5-inch is slightly flatter than that of the 8-inch howitzer (11½ lb. charge). Other comparisons will be found in the 7-pr. bronze and 8-inch howitzer (7 lb.), the 8-inch B.L. (II.), and 9·2-inch B. L. (I.), &c. The following data will enable some of the positions on the Table to be compared.

	$\log \frac{d^2}{w}$	M. V.	R.	α
3-pr. Hotchkiss ...	·014	1873	3813	8° 5′
8-inch R.M.L. ...	$\bar{1}$·5509	1384	3800	7° 58′
2·5-inch...	$\bar{1}$·9507	1440		
8-inch howitzer ...	$\bar{1}$·5509	956		
8-inch B.L., (II.) ...	$\bar{1}$·484	2030	8000	10° 44′
9·2-inch B.L., (I.) ...	$\bar{1}$·3478	1835	8000	10° 54′

It is evident that when there is but little difference in elevation and range in any two natures, any correction for height of trajectory should be practically the same for both, and proceeding on this

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assumption, diagonals of "similar trajectory" (the red ones which it will be seen appears to run parallel), have been drawn across Table I. and a Table (A) of corrections made out from such data as was available. The diagonals are referred to by letters (*b*, *c*, *&c.*,) and the necessary correction can be inferred for any position of the value of f in Table I., which is not much beyond those diagonals at present obtained.

The results obtained for this Correction Table are very reasonable, the corrections increasing with the range, and diminishing with the flatness of trajectory. They have been referred to the value of s, for the Table is primarily intended for the simple calculation of range and elevation and consequently the s is the first thing used. The corrections contained in this Table, it must be observed, were obtained from what is known as to the condition of things obtaining at the *end* of a horizontal range, so should not do for the calculation of all intermediate points,—this part of the subject will be considered subsequently.

The use of the Tables then so far is that they enable us to calculate the horizontal range, elevation and time of flight corresponding to any selected value of s, within the limits of the Tables. Since $s \propto \sec \alpha$ its value for small angles of elevation will not be very different from that of R (in feet), but generally the determination of α for a given R, and (especially) the converse, will have to be effected by a series of trials.

As an example, suppose it is required to determine the elevation for 5000 yards with the 2·5-inch jointed gun.

Take s somewhat larger than R, say $s = 3 \times 5500 = 16500$.

We have for data: $\frac{d^2}{w} = \frac{2{\cdot}5^2}{7}$; $\log \frac{d^2}{w} = \bar{1}{\cdot}9507$; M.V. = 1440.

Referring to Table I., $f = 12{\cdot}09$, and its position about one-fifth the distance between diagonals *c* and *d*. Correction for 16500 feet is therefore ·084.

Now by Bashforth: $\frac{d^2}{w} s = S_V - S_v$;

$$\frac{d^2}{w} 16500 = S_{1440} - S_v;$$

$$\log \frac{d^2}{w} = \bar{1}{\cdot}9507$$

$$\text{Correction} \quad - \quad \cdot 084$$

$$\bar{1}{\cdot}8667$$

$$\log 16500 = 4{\cdot}2175$$

$$4{\cdot}0842 = \log 12140$$

$$42884{\cdot}4 = S_{1440}$$

$$30744{\cdot}4 = S_v$$

$$30738{\cdot}7 = S_{566}$$

$$v = 566{\cdot}2 \text{ f.s.}$$

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Again,—

$$\frac{d^2}{w}t = T_{1440} - T_{566\cdot2}$$

$T_{1440} = 232\cdot1234$

$T_{566\cdot2} = 217\cdot1524$

$14\cdot971$ $\quad \log 14\cdot971 = 1\cdot1753$

Corrected $\log \frac{d^2}{w} = \bar{1}\cdot8667$

$1\cdot3086 = \log 20\cdot35$

$t = 20\cdot35$ secs.

Now to obtain a, we have,—

$$\sin a = \frac{h}{s} \text{ and } h = ft^2$$

$$\log \sin a = 2 \log t + \log f - \log s = \bar{1}\cdot4810$$

$$a = 17^\circ\ 37'$$

$R = s \cos a$ feet $\quad R = 5242$ yards.

The value assumed for s was too large to give 5000, but seeing that s is about 250 yards larger than R, making $s = 15750$ feet, and repeating the operations will probably give 5000 almost exactly. If however the object is to extend the range table the operations already performed have given one point for the "range curve."

But to carry on the illustration for the present purpose take $s =$ 15750 feet $= 5250$ yards, then correction $= \cdot076$; corrected $\log \frac{d^2}{w} =$ $\bar{1}\cdot8747$

$$\frac{d^2}{w}15750 = S_{1440} - S_v$$

$S_v = 42884\cdot4$

$- 11800$

$31084\cdot4$ $\quad v = 578.$

$$\frac{d^2}{w}t = T_{1\ 40} - T_{578}$$

$= 232\cdot1234$

$- 217\cdot7456$

$14\cdot3778$ $\quad t = 19\cdot19$

$\log \sin a = \bar{1}\cdot4510$ $\quad a = 16^\circ\ 25'$

$R = 15750 \cos 16^\circ\ 25'$ ft. $\quad R = 5036$ yds.

The results can now be extended in either direction for 100 yards or so by proportion. Thus we find at this range 1° 12′ alters range 206 yards; ∴ difference in elevation for 36 yards is $36 \times \frac{72}{206}$ min. $= 13'$. Elevation for 5000 yds $= 16^\circ\ 12'$.

The published range table only goes as far as 4000 yards; to com-

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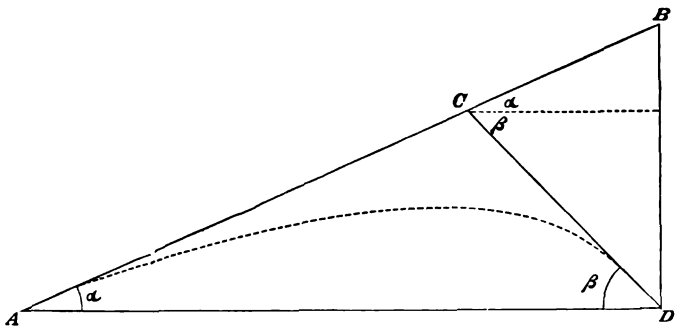
pare the results by this method with the table take $s = 12000$ ft., say, correction is ·026 and the results are—

a	$R.$	$t.$	
10° 55′	3928	13·7	by calculation,
10° 43′	3900	13·59	by range table,

the difference of elevation for 25 yards is 7′, difference of time ·12, which brings the agreement as to time almost exact, and the range within 15 yards.

The values of R, a and t having been thus calculated the remaining information usually required, viz., angle of descent, and remaining velocity, can also be obtained.

The v already obtained by Bashforth is not the actual remaining velocity, which is somewhat larger according to this method.



Referring to the general hypothesis the Bashforth v is supposed to act in the original direction AB, along which s is measured, it will therefore be distinguished here by the symbol $(s)\ v$. The actual v must be in the direction of the line of descent CD, and on the principle of the parallelogram of velocities should be compounded of the $(s)\ v$, and the vertical velocity induced by gravity which would be in the direction BD, *i.e.*, h, and it will be convenient to denote this velocity by $(h)\ v$.

Now since the vertical acceleration has been assumed *uniform* it is evident that the velocity it induces should be given by :—

$$(h)\ v = 2\,ft$$

and making $BD = (h)\ v$ and $CB = (s)\ v$ the direction of CD measured as an angle of descent β should be obtained by :—

$$\tan\beta = \frac{(h)\,v}{(s)\,v}\sec a - \tan a\,.$$

Applying these formulæ to the results just obtained for comparison with the range table we have :—

$$(h)\ v = 2 \times 12{\cdot}09 \times 13{\cdot}71 = 331{\cdot}4$$

the $(s)\ v$ obtained by Bashforth was $= 641{\cdot}4$

hence
$$\tan\beta = \frac{331{\cdot}4}{641{\cdot}4}\sec 10°\ 55' - \tan 10°\ 55'$$
$$= {\cdot}5261 - {\cdot}1929 = {\cdot}3332$$
$$\beta = 18°\ 26'.$$

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This is larger than that given by the range table, but agrees with the general results of the method. Thus if s is taken = 12300 feet (and correction in consequence ·030) the results are:—

a	R	t	$(s)\,v$
11° 22′	4020	14·17	634·9

this shows a difference of 27′ for 92 yards, and by the well known formula,

$$\frac{R \tan \delta a}{\delta R} = \tan \beta$$

we have for the angle of descent at 3928 yards.

$$\frac{3928 \tan 27'}{92} = \tan \beta,$$

whence $\beta = 18° 32'$.

The true remaining velocity may now be ascertained most simply in terms of the $(s)\,v$ and angles of elevation and descent thus:—

$$v = \frac{\cos a}{\cos \beta} (s)\, v;$$

in this particular instance the v at 3928 yards is

$$v = \frac{\cos 10° 55'}{\cos 18° 26'} 641{\cdot}4$$

$$= 664 \text{ f.s.};$$

this it will be seen is *considerably* larger than that given by the method employed on the range-table—the $(s)\,v$ itself was larger—and the question of remaining velocity may perhaps be considered as fairly debatable ground. To compare the general results of the method with the rest of the range-table, the following points have also been calculated:—

R	a ° ′	t	v	
300	0 20	0·6631	1283	Calculated
300	0 16	0·75	1279	Table
1995	3 49	5·741	853	Calculated
2000	4 9	5·74	852	Table
4020	11 22	14·17	659	Calculated
4000	11 7	14·07	617	Table

the corrections for diagonal c were, it may be observed, calculated from practice with the 8-inch howitzer, and the practice reports of the 2·5-inch gun have not been consulted, but it is believed that the time of flight column in the range-table was filled in from the practice reports and not calculated.

Calculation of intermediate Points.

To proceed now to the question of the determination of intermediate points in the trajectory. So long as no correction for height is

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necessary there is no difficulty. If the height of any point be denoted as usual by y this is given of course by the expression

$$y = s \sin \alpha - f t^2$$

but in this t is dependent on the $\frac{d^2}{w}$, and if any correction is necessary for "tenuity" it should be known from the first.

Now one or two assumptions have to be made. The first is that the correction at the summit of the trajectory will be the same as that at the end, since at the end the projectile may be considered simply to have traversed the same condition of atmosphere twice. If this is admissible it follows that in the ascending branch the corrections increase with the height of the point under consideration, while for the descending branch they remain practically constant. This of course is most important (if sufficiently correct) as it is generally points in the descending branch that are practically required.

Proceeding then on these assumptions the maximum heights of various trajectories, differing as largely as possible in character, have been computed and compared with the corrections found necessary in each case, with the following results:—

1. The corrections do appear to coincide roughly with equal heights of trajectory, and consequently the assumption that they are necessitated by a diminished resistance of the air appears justified.

2. They also appear within certain limits to follow the *Time of Flight*, from which it is inferable that the maximum height may be directly deduced from the time of flight. This being an entirely unexpected result, the subject was further investigated, and it then appeared that though the maximum height invariably follows the time, the correction does not. *This* diminishes gradually as the range increases, (for the same height of trajectory) and it has consequently been necessary to again refer to the diagonals of Table I.

3. By this method the maximum height occurs *in all cases* so near the point of half time that but little error in height is obtained by computing it for $\frac{1}{2}\ t$. For instance, the 8-inch howitzer with $R = 6246$, $\alpha = 30° 3'$, $t = 27{\cdot}32$, the maximum height is apparently at $t = 13{\cdot}5$ and is 3179 ft., taking $\frac{1}{2}\ t$, *i.e.* 13·66 secs., the height works out 3175 ft.

The results obtained in this way are given in Table B.

This Table (in conjunction with those that have gone before) will enable a very large class of problems to be worked out, some almost by mere inspection.

For instance the question was on an occasion raised as to what would be the elevation and range from a ship, necessary to hit a certain battary at Gibraltar which is 900 feet above the deck of the ship, the gun being a 10-inch R.M.L. say.

Now referring to Table B we see that the time of flight corresponding to a maximum height of 900 feet is 14·8 seconds.

Referring to the range table of the 10-inch R.M.L. (70 lb. charge) we find the elevation to give a time of 14·8 (on a horizontal range) is

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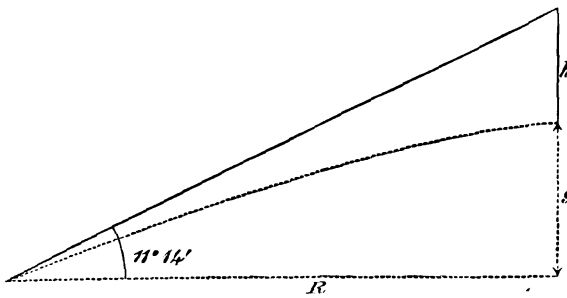
11° 14′ this is therefore the minimum elevation that will reach this height. The total horizontal range due to this height and time is by the range table 5330 *, but the distance that the ship must be from the battery is that due to the *summit* of the trajectory, and must be calculated. Probably the simplest way to do this is to find the value of h for the summit time (*i.e.* $\frac{1}{2} \times 14{\cdot}8$) and then we have



$$R = (h + 900) \cot 11° 14'$$

$h = ft^2 = 14{\cdot}43 \times 7{\cdot}4^2$ (f corresponding by Table I. with M.V. 1380 and $\log \frac{d^2}{w} = \bar{1}{\cdot}39$); whence

$$R = 1689 \cot 11° 14' = 8506 \text{ feet},$$
$$= 2835 \text{ yards}.$$

This is of course the horizontal range to a point vertically beneath the battery; the direct range—if required—being:—

$$\sqrt{(300^2 + 2835^2)} = 2851 \text{ yards},$$

and the elevation 11° 14′ is *quadrant* elevation. If the battery is to be

---

* To take this opportunity of again comparing the agreement of the results by this method and the range table we have the following data to calculate the range and elevation corresponding to $t = 14{\cdot}8$

M.V. = 1379; $\log \frac{d^2}{w} = \bar{1}{\cdot}3872$ $\left(\log \frac{10^2}{410}\right)$; $f = 14{\cdot}43$ (Table I.); correction = ·044 (Table B).

and $\frac{d^2}{w} 14{\cdot}8 = T_{1379} - T_v$

corrected $\log \frac{d^2}{w} = \bar{1}{\cdot}3432$ $\qquad T_v = 231{\cdot}9139$

$\log 14{\cdot}8 = 1{\cdot}1703$ $\qquad -3{\cdot}262$ $\quad (= \log^{-1} \cdot 5135)$

$\qquad\qquad \cdot 5135$ $\qquad 228{\cdot}6519$ $\quad = T_{940{\cdot}6}$

$\qquad\qquad\qquad\qquad\qquad\qquad$ (s) $v = 940{\cdot}6$

$\frac{d^2}{w} s = S_{1379} - S_{940{\cdot}6}$

$= 42589{\cdot}3$ $\qquad \log 3588 = 3{\cdot}5549$

$- 39000{\cdot}9$ $\qquad \log \frac{d^2}{w} = \bar{1}{\cdot}3432$

$3588{\cdot}4$ $\qquad\qquad 4{\cdot}2117 = \log s$

$$\sin \alpha = \frac{ft^2}{s} = \frac{14{\cdot}43 \times 14{\cdot}8^2}{s}$$

$$\alpha = 11° 12'$$

$$R = s \cos \alpha \text{ ft.} \qquad R = 5323 \text{ yards.}$$

The agreement in this case could hardly be more exact on all points. This is a fair test case as no reference was made to the practice with 10-inch R.M.L. in compiling the tables.

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laid on by the tangent sights, the angle (γ) subtended by the height of the battery is given by:

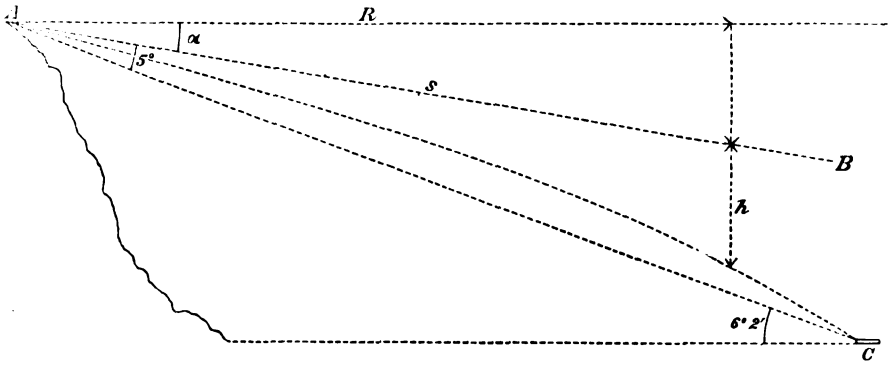
$$\tan \gamma = \frac{300}{2835} \qquad \gamma = 6° 2'$$

and tangent angle of elevation is

$$\alpha - \gamma = 11° 14' - 6° 2' = 5° 12'.$$

Now it will be seen by the range table that the elevation for an object on the same level with the gun at a range of 2851 is 5°—the extra 12′ is therefore the difference in elevation—in this case—necessitated by the difference in level of gun and object, and arrived at by a not very laborious process—however correct it may be.[1] The results would probably be good enough at all events to commence practice with, and it is hoped that estimates of this sort may not be considered without practical value, the present one for instance suggesting a knowledge of the "non-effective zone" within which ships of a certain power cannot attack such elevated batteries, unless their mountings admit of a very considerable elevation, to enable them to deliver an upward fire, &c., &c.[2]

The calculations for the return fire from the battery are not so simple and must be done by trials.



In this case, if α be the quadrant angle of *depression* we have for the position of the projectile at the end of any given t and s

$$y = s \sin \alpha + h = s \sin \alpha + ft^2$$

y being as before, the vertical distance of the projectile from the horizontal through the muzzle. This, in this instance, we know we want to get = 900 feet, so we may put:—

$$900 = s \sin \alpha + f t^2$$

we know the angle of depression of the ship (6° 2′) and consequently

[1] The *calculated* elevation for 2851 is 5° 3′ which makes the difference only 9′.

[2] It is believed that none of *our* Sea Service 10-inch mountings would admit of this battery being hit at all.

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the range $R = 2835$ yards, now $s \sin \alpha$ may be written $R \tan \alpha$ and we have:—

$$900 = 3 \times 2835 \tan \alpha + 14{\cdot}43\ t^2 \text{ *}$$

Suppose we try the tangent elevation due to the direct range (2851) by the range table viz., 5°, α is then $6{\cdot}2 - 5° = 1°\ 2'$, and we have:—

$$t^2 = \frac{900 - 3 \times 2835 \tan 1°\ 2'}{14{\cdot}43}$$

whence $t = 7{\cdot}193$ secs.

this, then, is the time that a 10-inch R.M.L. projectile fired from a height of 900 feet, takes to strike the level of the ship when fired with a quadrant depression of 1° 2'. To ascertain whether it strikes at the right range the value of s corresponding to $t = 7{\cdot}193$ must be calculated by Bashforth. In this case the s works out 8674 feet—the "correction" being taken as for a descending branch from a height of 900, and therefore the same as before. We have now:—

$$R = s \cos \alpha = 8674 \cos 1°\ 2' \text{ feet.}$$

which gives a horizontal range of 2891 yards, somewhat larger than that required—as might be expected—though only 56 yards.

Without going to the trouble of re-calculating with a larger value for α the correction required may be taken from the range table which shows a difference of 7', say, for 56 yards at this range. The correct tangent elevation for firing down is therefore 4° 53'. The correction in elevation thus appears to be almost the same[1] for firing up as for firing down—in the one case added, in the other subtracted. The principal difference in the results however, is seen in the time of flight, and energy of the blow delivered. The calculated results are here drawn up for comparison.

	R (direct)	α (tangent)	t	v	Energy foot tons.
Firing down	2851	4° 53'	7·153	1093	3398
" horizontally ...	2851	5° 3'	7·202	1056	3171
" up	2851	5° 12'	7·4	1041	3078

This will probably suffice to illustrate the application of the method, which it will be seen requires but little ingenuity to bring ordinary problems within its scope, some even which by the known methods are almost incalculable, and all of which, thus treated, are enormously simplified. Table B has developed itself into an especially useful form, and lends itself particularly to the calculations concerning points in the descending branch. It would seem as if an extra column of "maximum height of trajectory" might be advantageously added to any range-table directly from this one.

The symbols and formulæ are here drawn together into a convenient form for reference.

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* $f = 14{\cdot}43$ supposing the battery also armed with 10-inch R.M.L. guns and full charge used.

[1] *Vide* note preceding page.

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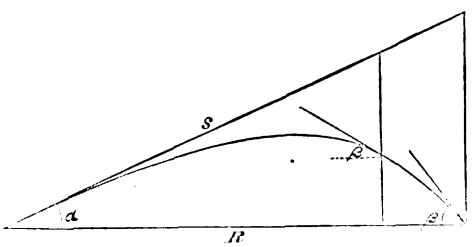
The symbols are,—

α = Quadrant angle of elevation or depression.
β = " " descent.
R = Horizontal range from muzzle to point under consideration (horizontal co-ordinate) in *yards*.
y = Vertical co-ordinate of point in *feet*.
s = Distance by Bashforth's Tables corresponding to time t – *feet*.
t = Time by Bashforth's Tables corresponding to distance s – *seconds*.
V = Muzzle Velocity.
v = Remaining Velocity at end of time t, and distance s.
$(s)v$ = Remaining Velocity *by Bashforth's Tables*, corresponding to t or s.
$(h)v$ = Vertical Velocity induced in time t.
f = ($\frac{1}{2}$) Vertical acceleration due to retarded gravity by Table I., and Appendix.
d = Calibre in *inches*.
w = Weight of projectile in *pounds*.
σ = Correction to be applied in using Bashforth's Tables by Tables A and B.

The formulæ are :—

(1) When α is elevation :—



$y = s \sin \alpha - ft^2$ for any point ;

$\therefore \sin \alpha = \frac{ft^2}{s} + \frac{y}{s} = \frac{ft^2}{s}$

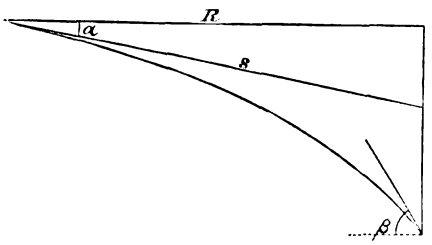
where $y = 0$ (*i.e.*, at end of range) ;

$R = \frac{s \cos \alpha}{3}$ ($\frac{1}{3}$ to get yards)

$(h)v = 2ft$

$\tan \beta = \frac{(h)v}{(s)v} \sec \alpha - \tan \alpha.$

(2) When α is depression :—



$y = s \sin \alpha + ft^2$

$\tan \beta = \frac{(h)v}{(s)v} \sec \alpha + \tan \alpha,$

$\sin \alpha = \frac{y - ft^2}{s}.$

others as for (1).

The Bashforth formulæ may be written :—

$$(\log \frac{d^2}{w} - \sigma) + \log s = \log \{S_V - S_v\}$$

and

$$(\log \frac{d^2}{w} - \sigma) + \log t = \log \{T_V - T_v\}$$

but so long as it is remembered that σ has to be subtracted from $\log \frac{d^2}{w}$ before using the latter that is all that is required.

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The values of f in Table I. may be calculated, if desired, by the following formula:—

$$f = 16{\cdot}1 - 4\left(\log \frac{d^2}{w} - \overline{1}{\cdot}35\right) - {\cdot}0017\,(V - 500),$$

in which it is assumed that f can never be made to exceed 16·1 and $\log \frac{d^2}{w}$ be not less than $\overline{1}{\cdot}35$.

The values of f in Table I., Appendix, beyond the time of 9 secs. are given by:—

$$f = 14 - {\cdot}06\,(t - 9).$$

As regards the general applicability of the method, it has not appeared necessary to place any restrictions, except for ranges with the smaller pieces which have a time of flight less than 9 secs., which are apt to be most uncertain. The Tables have been drawn up to give the actual elevations required, and no account has been taken of "jump." One reason for this is that the calculations for determining jump are made dependent on the assumption that at the beginning of the trajectory the vertical acceleration may be taken as that due to gravity unimpaired, and the general results of this "investigation" go to show that the assumption is not at all necessarily true. Until therefore a more satisfactory method of ascertaining the true jump is obtained, calculations for the shorter ranges must still remain uncertain, and the whole subject more or less shrouded in doubt. For the rest it must be said that the Tables have been derived from practice with our service ordnance and projectiles, and it is impossible to say whether they may be applicable to those of other design or not.

One great point in favour of the method is that it is applicable to all natures of fire as regards elevation and range; being, if anything, rather more certain in its action for howitzer-fire than for the very flat trajectories.

In conclusion, it is perhaps unnecessary to say that the subject is not considered by any means exhausted, there are points which are not at all clear, and it is quite possible that for greater accuracy a complete revision of Table I., may be necessary. It will be observed that to form an estimate by this method two things have to be determined—the time of flight corresponding to a given s (or *vice versâ*) and the ($\frac{1}{2}$) mean vertical acceleration f. With regard to the first, it is believed that the correction tables will be found to give *very accurate results* for common shell;[1] they have been gradually formed and checked from time to time with fresh data. With regard to the second, it is obviously unsatisfactory to have a break in the continuity of Table I. and its appendix, and the state of things thus indicated is avowedly dubious, but that cannot be helped at present; the endeavour has merely been to set forth faithfully the state of things

[1] The 13-pr. is the only piece examined to which they are quite inapplicable, this requires no *correction*. It is not proposed to discuss this at present, though the explanation does not seem far to seek.

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as they appear to exist, and the present Table is offered till more becomes known.

The appendix values were obtained from the 13·5-inch B.L., they agree very closely with the 11-inch R.M.L. (log $\frac{d^2}{w} = \bar{1}\cdot345$), and that they are also available for the 17·72-inch R.M.L. may be judged from the following :—

At Gibraltar on the 5th November, 1884, a round was fired with 7° quadrant elevation, the only one yet fired for range with full charge from the 100-ton. The "height of gun above mean sea level" was recorded as "70 feet (about)," and the range attained 5125 yards. The tangent elevation to the point of impact was therefore presumably 7° 15′, and the value of s in this case would be 5125 sec 7° 15′ = 5166 yards.

To compare at once the results by this method let us select the value $s = 5166$ yards, and ascertain the elevation and range corresponding to it.

We have for data; published M.V. 1548; log $\frac{d^2}{w} = \bar{1}\cdot1960$ $\left(\log \frac{17\cdot72^2}{2000}\right)$; correction (Table A) = ·019.

$$\frac{d^2}{w}\, s = S_{1548} - S_e$$

Corrected log $\frac{d^2}{w} = \bar{1}\cdot1770$ $\qquad = 43377\cdot6$

log 3 × 5166 = 4·1903 $\qquad - \ 2330$

$3\cdot3673 \qquad 41047\cdot6 = S_{1120}$

$$\frac{d^2}{w}\, t = T_{1548} - T_{1120}$$

$$= 232\cdot4539$$

$$230\cdot6648$$

$1\cdot7891 = \log^{-1}\cdot2521$

$\log \frac{d^2}{w} = \bar{1}\cdot1770$

$\overline{1\cdot0751} = \log t$

$t = 11\cdot89.$

$\sin \alpha = \frac{f t^2}{s}$, and by the Appendix, Table I., for $t = 11\cdot89$, $f = 13\cdot83$,

hence $\sin \alpha = \frac{13\cdot83 \times 11\cdot89^2}{3 \times 5166}$ $\quad \alpha = 7°\ 14'$;

the range of course is 5166 cos 7° 14′ = 5125.

Results :—

	α	R
Calculated	7° 14′	5125.
Observed	7° 15′	5125.

On the strength of this and other satisfactory tests, the following skeleton range table is predicted for the 111-ton B.L.

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TABLE A. Corrections to be applied to log $\frac{d^2}{w}$ for height of trajectory.

s-yds.	*b*	*c*	*d*	*e*	*g*	*k*	*l*	*n*
2000	(?)	—	—	—	—	—	—	—
2500	·043	—	—	—	—	—	—	—
3000	·080	—	—	—	—	—	—	—
3500	·103	—	—	—	—	—	—	—
4000	·124	·029	·01	—	—	—	—	—
4500	·144	·053	·029	·015	—	—	—	—
5000	·165	·072	·046	·029	·017	·010	·0	—
5500	—	·089	·063	·043	·033	·024	·013	·0
6000	—	·104	·078	·057	·049	·037	·024	·011
6500	—	·118	·093	·071	·061	·048	·033	·017
7000	—	·132	·107	·085	·072	·059	·041	·022
7500	—	·144	·120	·099	·083	·069	·048	·025
8000	—	·156	·132	·113	·093	·076	·052	·028
8500	—	·167	·144	·125	·102	·083	·057	·030
9000	—	·178	·155	·136	·111	·090	·062	·035
9500	—	·187	·165	·147	·120	·097	·066	·037
10000	—	—	·174	·158	·128	·103	·071	·037
10500	—	—	·183	·167	·135	·109	·075	·040
11000	—	—	·192	·177	·143	·114	·079	·043
11500	—	—	·200	·186	·150	·119	·083	·044
12000	—	—	—	·193	·156	·124	·086	·046
12500	—	—	—	·201	·163	·129	·090	·049
13000	—	—	—	·209	·169	·134	·093	·051
13500	—	—	—	·216	·175	·138	·097	·054
14000	—	—	—	·223	·180	·143	·100	·056
14500	—	—	—	·230	·186	·147	·103	·058
15000	—	—	—	—	·191	·152	·106	·061
15500	—	—	—	—	·196	·156	·110	·064
16000	—	—	—	—	·201	·160	·113	·066
16500	—	—	—	—	·206	·164	·117	·068
17000	—	—	—	—	·211	·168	·120	·071
17500	—	—	—	—	—	·172	·123	·073
18000	—	—	—	—	—	·175	·126	·075

Example of use.—Given log $\frac{d^2}{w} = \bar{1}\cdot7301$, M.V. = 1750—to find necessary correction for a value $s = 5000$ yards.

In Table I., opposite $\bar{1}\cdot73$ and under 1750 value of f appears $= 12\cdot44$; the position is about one-third of the distance between diagonals *e* and *d*.

In Correction Table, opposite $s = 5000$, correction under *e* is ·029, under *d* is ·046. Difference of ·046 and ·029 is ·017

$$\frac{1}{3} \times \cdot017 = \cdot006$$

Correction is therefore $= \cdot029 + \cdot006 = \cdot035$.

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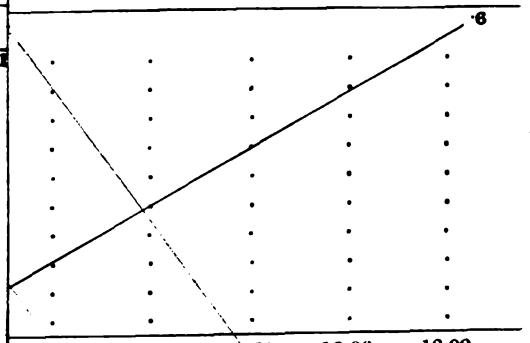
Tables A. and B.

M	2000	2100	2200	2300	2400
log					



13·55	13·39	13·22	13·06	12·90
13·47	13·31	13·14	12·98	12·82
13·39	13·23	13·06	12·90	12·74
13·31	13·15	12·98	12·82	12·66
13·23	13·07	12·90	12·74	12·58
13·15	12·99	12·82	12·66	12·50
13·07	12·91	12·74	12·58	12·42
12·99	12·83	12·66	12·50	12·34
12·91	12·75	12·58	12·42	12·26
12·83	12·67	12·50	12·34	12·18
12·75	12·59	12·42	12·26	12·10
12·67	12·51	12·34	12·18	12·02
12·59	12·43	12·26	12·10	11·94
12·51	12·35	12·18	12·02	11·86
12·43	12·27	12·10	11·94	11·78
12·35	12·19	12·02	11·86	11·70
12·27	12·11	11·94	11·78	11·62
12·19	12·03	11·86	11·70	11·54
12·11	11·95	11·78	11·62	11·46
12·03	11·87	11·70	11·54	11·38
11·95	11·79	11·62	11·46	11·30
11·87	11·71	11·54	11·38	11·22
11·79	11·63	11·46	11·30	11·14
11·71	11·55	11·38	11·22	11·06
11·63	11·47	11·30	11·14	10·98
11·55	11·39	11·22	11·06	10·90
11·47	11·31	11·14	10·98	10·82
11·39	11·23	11·06	10·90	10·74
11·31	11·15	10·98	10·82	10·66
11·23	11·07	10·90	10·74	10·58
11·15	10·99	10·82	10·66	10·50
11·07	10·91	10·74	10·58	10·42
10·99	10·83	10·66	10·50	10·34
10·91	10·75	10·58	10·42	10·26

APPENDIX TO TABLE I.

t. secs.	f.
1	15·72
2	15·4
3	15·1
4	14·83
5	14·6
6	14·4
7	14·26
8	14·12
9	14·00
10	13·94
11	13·88
12	13·82
13	13·76
14	13·70
15	13·64
16	13·58
17	13·52
18	13.46
19	13·40
20	13·34
21	13·28
22	13·22
23	13·16
24	13·10
25	13·04
26	12·98
27	12·92
28	12·86
29	12·80
30	12·74

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TABLE B.—Corrections for log $\frac{d^2}{w}$ in terms of maximum height of trajectory and Time of Flight.

Maximum height of trajectory.	Correction for log $\frac{d^2}{w}$ *				Time of Flight. †
feet.	*c, d and e.*	*g*	*k*	*l*	secs.
100	—	—	—	—	3·1
200	—	—	—	—	5·7
300	—	—	—	—	7·8
400	·0	·0	·0	·0	9·6
500	·013	·013	·013	·013	11·0
600	·023	·023	·023	·021	12·2
700	·031	·031	·031	·028	13·2
800	·038	·038	·038	·033	14·1
900	·044	·044	·044	·038	14·8
1100	·054	·054	·054	·045	16·0
1300	·064	·064	·064	·051	17·2
1500	·073	·073	·073	·056	18·3
1700	·082	·081	·080	·060	19·4
1900	·090	·088	·086	·064	20·4
2100	·100	·096	·093	·067	21·5
2300	·109	·103	·098	·070	22·6
2500	·118	·109	·103	·072	23·7
2700	·126	·114	·106	·074	24·7
2900	·134	·118	·110	·076	25·6
3100	·143	·124	·113	·078	26·6
3300	·150	·128	·115	·080	27·6

* The correction is to be subtracted from the *log* $\frac{d^2}{w}$.

† This is the time to the *end of the horizontal range* corresponding to the maximum height The time to the summit itself will be half this.

PREDICTED RANGE TABLE.

16·25-inch B.L. Gun.
Muzzle Velocity,—2100 f.s.
Weight of projectile,—1800 lb.

Range.	Elevation.	Time of flight.
yards.	° ′	seconds.
1000	0 39	1·474
2000	1 20	3·042
3000	2 4	4·706
4000	2 52	6·482
5000	3 44	8·379
6000	4 41	10·39
7000	5 40	12·5
8000	6 52	14·78
9000	8 10	17·19
10000	9 37	19·8
11000	11 11	22·6
12000	12 56	25·63
13000	14 48	28·82

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A DICTIONARY OF EXPLOSIVES.

BY

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Introductory.

In the following pages I propose to set forth a "Dictionary of Explosives," which comprises all those which have, to my knowledge, been used or proposed to be used. The list includes a good many which are obviously unfit for practical purposes, and some which are merely curiosities in a chemical sense. All however are given without distinction.

Those which are, or have been, licensed for use in the United Kingdom will be specially noted as "authorised explosives," a term which signifies that they are, or have been, "authorised to be manufactured for general sale or imported for general sale," under the Explosives Act, 1875.

It may not be amiss to point out here that the authorization of an explosive in no way concerns its commercial or practical value. It simply means that a given explosive has, after due examination and testing, been found to be reasonably safe under ordinary conditions of transport, storage, and use.

I have divided the list into eight classes, as follows:—

I. Gunpowder, ordinarily so-called.
II. Nitrate mixtures other than gunpowder.
III. Chlorate mixtures.
IV. Nitro-compounds containing nitro-glycerine. This includes the great dynamite class.
V. Nitro-compounds not containing nitro-glycerine, *e.g.*, guncotton.
VI. Explosives in which picric acid or a picrate is a main constituent.[1]
VII. Explosives of the Sprengel type in which the principle is the admixture of an oxidising with a combustible agent (at the time of, or just before, being required for use), the constituents of the mixture being themselves non-explosive.
VIII. Miscellaneous explosives.

[1] Picric acid is itself a nitro-compound, and explosives containing it or picrates would strictly fall into Class V., but for the sake of convenience I have placed them in a small separate class.

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I do not pretend that in every case the limits of each class are very sharply and definitely defined. In many cases one class merges into another, but I have observed the foregoing classification as a whole, and been guided by the main distinctive features of the various explosives.

It will be apparent as the lists are gone through how often the same, or practically the same, idea has been patented and re-patented, and this is especially the case in the Chlorate mixture class. Further it will be seen in the dynamite class how many explosives though passing under different names are to all intents and purposes identical.

With Class I. (gunpowder) I have dealt very slightly indeed, for the literature on that head is very copious, and I have merely indicated a few propositions which have been made with respect to alterations from the ordinary methods of manufacture.

To each class I have prefixed a short introductory chapter dealing with the leading features of that class, and in the alphabetical lists I have given in almost every case the authority for the information concerning each individual explosive. The main authorities quoted are abbreviated as follows:—

The number and date of an English patent specification is given thus:—

Spec. No. 139, 18. 1. 62.

"D" refers to Desortiaux' translation (with additions) of the work of Drs. J. Upmann and E. von Meyer.[1]

"T" refers to Drinker's Tunnelling.[2]

"M" refers to "Notes on the Literature of Explosives," by Professor C. E. Munroe, U.S.N.A., of the U.S. Naval Institute, Annopolis.

"Eissler" refers to "Modern High Explosives.[3]

"B" refers to Berthelot. "*Sur la force de matières explosives.*" 3me Edition. Ed. Gauthier-Villars. Paris.

I would call particular attention to the fact that I do not pretend to enumerate every form of matter possessed of explosive properties. Of these the quantity is innumerable, and the practical chemist is acquainted with scores of combinations which under certain circumstances are powerfully and dangerously explosive. To take the simplest instance, a mixture of oxygen and hydrogen in the proportions requisite to form water, is, weight for weight, one of the most powerful explosives known; while the very water created by the combination of these gases will, if closely confined and heated, give rise to explosion, as in the case of boiler accidents. Many other well-known gaseous mixtures, such as coal gas and air, are highly explosive, but such will not be mentioned here. Some of the more interesting chemical combinations

[1] *Traité sur la poudre, les corps explosives, et la pyrotechnie.* Paris, 1878.

[2] *Tunnelling, Explosive Compounds, and Rock Drills,* by Henry S. Drinker. 2nd Edition. John Wiley and Sons, New York, 1882.

[3] *The Modern High Explosives,* by Manuel Eissler. John Wiley and Sons, New York, 1884.

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are given in the miscellaneous class, but as a rule I have followed the definition given in the Explosives Act, 1875, Sec. 3, which states:—

"The term "explosive" in this Act,—

(1) "Means gunpowder, nitro-glycerine, dynamite, guncotton, "blasting powders, fulminate of mercury and other metals, "coloured fires and every other substance, whether similar "to those above-mentioned or not, *used or manfactured with* "*a view to produce a practical effect by explosion or a pyrotechnic* "*effect*,[1] and

(2) "Includes fog-signals, fireworks, fuzes, rockets, percussion "caps, detonators, cartridges, ammunition of all descriptions, "and every adaptation or preparation of an explosive as "above defined."

Class I.—(Gunpowder).

I do not propose to dwell at length on this class for the reason previously stated. While during the past few years the manufacture and treatment of gunpowder for artillery purposes has received the closest attention resulting in the production of powders differing most widely in physical characteristics from each other, and from the sweet simplicity which characterized the old powders in use some quarter of a century ago, the actual proportion of ingredients for black gunpowder has varied but little if at all, and now as then the composition of nearly all descriptions of service gunpowder consists of the time honoured 75 parts of saltpetre, 15 of charcoal, and 10 of sulphur.

While some Continental countries follow this formula, others somewhat vary the proportions. For instance the ordinary French service gunpowder consists of the ingredients in the proportion of "*six, as, as,*" or saltpetre 75, charcoal 12·5, and sulphur 12·5.

Ordinary blasting powder[2] differs, broadly speaking, from the higher classes of powder in containing less saltpetre and in being milled a shorter time, as a rule; also less attention is paid to the charcoal used.

Briefly, the manufacture of gunpowder may be summarized as consisting of the following operations:—

1. Mixing the previously purified and sifted ingredients to form a "green" or "unworked" charge.

---

[1] The point of the definition in regard to substances not detailed by name lies in the words which I have placed in italics.

By Sec. 104 of the Act, power is reserved to Her Majesty in Council to declare that any substance which appears to Her "to be specially dangerous to life or property by reason either of its explosive properties, or of any process in the manufacture thereof being liable to explosion" may "be deemed to be an explosive within the meaning of this Act."

[2] Blasting powder and gunpowder are sometimes spoken of by retail dealers as if quite different substances. They are of course identical, or rather blasting powder is simply a cheaper and inferior class of gunpowder. At the same time Desortiaux (p. 600) points out that not only is a powder rich in charcoal cheaper than ordinary powder, but that it may be expected to furnish a larger volume of gas when exploded, and he quotes Piobert in support of this theory. Hence for blasting purposes it is quite possible that a cheap powder poor, comparatively speaking, in saltpetre may be equal or superior to one of the ordinary composition.

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2. Milling (incorporating) the mixture to form mill-cake ("ripe" or "worked" charge).
3. Breaking down mill-cake. (This is omitted in many factories).
4. Pressing.
5. Granulating or "corning."
6. Dusting.
7. Glazing.
8. Drying in a stove.
9. Finishing or final dusting.

In different factories the system employed in each of the above operations may differ in some degree, and in one or two cases the order of one or two processes may be changed, but the above is a sufficiently accurate general description.[1]

Of the ingredients mentioned, the charcoal is by far the most important in one sense, for on its treatment depends much of the character of the gunpowder of which it forms a part. The material from which the charcoal is prepared and the methods of carbonising this material require most anxious attention, and the popular saying that "gunpowder all depends on the charcoal" is not far wrong.[2]

The properties of a given powder manufactured from given ingredients in given proportions depend on the physical characteristics of the finished powder, *e.g.*, length of milling, pressure given, amount of glazing, moisture, size and shape of grains or blocks, and their gravimetric density. These and other points go to make the art of making a really high-class powder suitable for a given task a matter of no small difficulty, as is shown by the care now found requisite in the manufacture as compared with the somewhat haphazard methods employed some years ago.

It would be impossible, and indeed out of place, here, to give at any length the history and manufacture of gunpowder embracing the now numerous varieties of that explosive, and I will therefore merely indicate a few variations from the ordinary methods of manufacture:—

Brown Powder is a special variety of gunpowder now largely used with heavy ordnance. Its manufacture originated in Germany, but is now carried on in this country. It differs from ordinary gunpowder in the proportions of its ingredients, which are for the description used in this country for military purposes:—

Saltpetre	...	...	79 parts
Sulphur	...	...	3 "
Charcoal	...	...	18 "

The charcoal used is usually made from straw carbonized in a special manner, the details of which are kept secret.

[1] Of course special varieties of powder, *e.g.*, Prism powders, require exceptional details of treatment. *e.g.*, no glazing is required, as the prisms are pressed from grain powder.

[2] Pure saltpetre and pure sulphur obviously admit of no alteration by treatment consistent with retaining their purity, but charcoal may be made of innumerable varieties.

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There are also some other peculiarities in the method of manufacture of this powder which cannot be given here. The finished powder is in the form of hexagonal prisms compressed from grain powder and having an axial perforation.

This powder gives very high velocities combined with moderate pressures on the gun. It is much less readily ignited than the ordinary powder and burns without explosion (so far as is yet ascertained) in the open. Cartridges made up with it require a small primer of black powder to start the action.

Other forms of brown powder have been recently introduced for sporting purposes.

COCOA POWDER, *see* BROWN POWDER.

DAVEY AND WATSON proposed to impregnate gunpowder with liquid or gaseous hydrocarbons or melted solid hydrocarbons. (Spec. No. 2641, 29. 7. 74.)

DRAYSON proposed to dissolve saltpetre in half its weight of warm water and to mix the solution with the requisite proportions of sulphur and charcoal in the mill. The ingredients thus mixed were to be ground, dried, and finished in the usual manner. (Spec. No. 2427, 31. 10. 55.)

In a subsequent specification he proposed to inject steam into a mixture of the usual ingredients enclosed in a vessel and in quantities sufficient to give adhesiveness to the composition. He proposed further to grain the powder direct from mill-cake instead of first pressing it in the usual way. (Spec. No. 292, 4. 2. 64.)

Drayson's process was tried at the Dartmoor Gunpowder Mills, but abandoned chiefly in consequence of a serious explosion.

GOODYEAR proposed to employ india-rubber or gutta-percha (apparently in lieu of charcoal) in the manufacture of gunpowder. (Spec. No. 1703, 26. 7. 55.)

GREENE reproduced Drayson's process with the addition of mixing the ingredients in a vacuum or partial vacuum (T. p. 103.)

GÜTTLER proposed to make cartridges of compressed blasting powder by cementing the grains together with dextrine. He used a brown-red charcoal made from wood free from resin at a temperature of about 290° C. This charcoal was said to have the formula $C_8 H_4 O_2$. (M., No. V., p. 749.)

HODGE injected steam into the mixed ingredients of gunpowder with a view of dissolving the saltpetre and thoroughly combining the ingredients. (Spec. No. 2227, 22. 8. 57.)

HUNT proposed to mix the ingredients with sufficient water to make a very thin paste and to combine them in this condition in a revolving drum suitably fitted. (Spec. No. 3775, 12.12.72.)

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MAXWELL simply diminished the amount of saltpetre "4 per-cent. more or less" and used spirit, or spirit and water, instead of water alone in liquoring. (Spec. No. 1066, 27. 4. 60.)

MEURLING, *see* NORDENFELT.

NEUMEYER proposed gunpowder consisting of—

Saltpetre	75·00 parts
Charcoal	18·75 "
Flower of sulphur	6·25 "

He preferred charcoal made from birchwood, and soaked the charcoal in soda-lye. He claimed that gunpowder thus made burnt quietly and slowly when unconfined, but had equal force to ordinary powder when confined. (Spec. No. 1636, 17. 6. 65.)

He afterwards proposed a mixture of—

Saltpetre	72 parts
Charcoal	18 "
Flower of sulphur	10 "

abandoned the use of soda-lye and mixed his ingredients with 40 per cent. of water in a drum, fitted with revolving arms, for 15 minutes. The resulting compound was simply dried and stated to be then fit for use. (Spec. No. 1408, 13. 5. 67, and D. p. 601.)

NORDENFELT, in conjunction with MEURLING, proposed to manufacture gunpowder in which he employed a brittle substance prepared from cotton or other woody fibre by treating it with hydrochloric acid gas. This substance is thoroughly mixed with the proper amount of a saturated solution of sulphur in carbon bisulphide in a closed vessel provided with a mechanical agitator. The dried mixture of carbon and sulphur is saturated with an aqueous solution of saltpetre, and the compound dried and finished as usual.

The brittle substance mentioned above would appear to be hydrocellulose, as described by Girard, or fulminose, as described by Blondeau. It is an isomeric modification of cellulose and is produced by the action of acids or heat on that substance. It is extremely brittle. (M., No. I., p. 311. No. X., p. 195). (Spec. Nos. 6514–15, 18. 4. 84, and Watts' Dic. of Chem.)

OLIVER substituted peat for charcoal, and, in cases where an extra strong powder was required, substituted chlorate of potash mixed with a small amount of bees-wax, tallow, or resin for the sulphur. (Spec. No. 1800, 10. 6. 69.)

STONES, like Oliver, whom he considerably preceded, also proposed to use charred peat in the manufacture of gunpowder. (Spec. No. 12,990, 7. 3. 50.)

WATSON, *see* DAVEY.

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WIENER proposed to mix the ingredients of gunpowder in a dry state and subject them to action of a steam-heated press at a temperature of about 250° F. The sulphur melted at this temperature and became thoroughly distributed throughout the mixture, converting the whole into a compact homogeneous black cake. (Spec. No. 3731, 17. 11. 73.)

Experiments were tried with this method of manufacture at Woolwich in 1878. The prospective advantages claimed were—

1. Decrease of the power of absorbing moisture.
2. Economy of manufacture, by doing away with stoves and mills.
3. Diminution of the danger of manufacture due to the presence of small quantities of gunpowder in any one working building.

The English experiments failed however to produce a satisfactory powder, and it was ascertained that in the manipulation by Wiener (Colonel Viner) the mixture had been raised to the fuzing point of saltpetre, which approximates to the firing point of gunpowder, and that several explosions had occurred. Consequently the matter was dropped, but a few experiments were tried with ordinary powder heated to the melting point of sulphur, the idea being to coat each grain with a film of sulphur or allow the latter to penetrate the charcoal. The trials were fairly successful, but not to such an extent as to warrant further experiments on a large scale. Gunpowder treated in this way was called "Baked Powder." (Reports of Com. on Explos. Sub., 1880–1.)

CLASS II.—(NITRATE MIXTURES OTHER THAN GUNPOWDER).

Of the explosives detailed in this class a very large number are simply modifications of ordinary gunpowder and differ from the latter only in the proportion of the ingredients, or by the addition of some other ingredients.

In many cases the main point is the substitution of other nitrates for the whole or for a portion of the nitrate of potash in ordinary gunpowder. Such nitrates are those of sodium, barium, and ammonium.

Sodium nitrate (Chili saltpetre) contains 56·47 p.c. of oxygen; ammonium nitrate contains 60 p.c.; potassium nitrate, 47·48 p.c.; and barium nitrate, 36·78 p.c.

It would, therefore, at first sight appear to be highly advantageous to substitute one of the two first named for saltpetre in gunpowder. Unfortunately, however, both of them are extremely hygroscopic, especially the ammonium nitrate, and consequently gunpowder made with them would under ordinary conditions soon become useless from damp absorbed from the atmosphere. In a hot dry climate nitrate of

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soda powders, especially if made only a short time before being required for use would doubtless be valuable[1] and be cheaper than gunpowder, and such powders were used to a considerable extent in the construction of the Suez Canal. Absolutely pure nitrate of soda is stated not to be unduly deliquescent, but the material as found in commerce contains other salts which are supposed to induce this property, and are difficult to remove by any reasonably economical process. The salt however is indirectly largely and increasingly used in the manufacture of gunpowder, for by the simple process of boiling it with chloride of potassium,[2] it is converted into nitrate of potash which is retained in the hot solution while chloride of sodium is deposited. The principle of the process is the general rule that if two salts are dissolved together which can form by exchange of their metals a salt less soluble in the liquid that salt will be deposited. Thus :—

$$Na.\ NO_3 + KCl = KNO_3 + Na\ Cl.$$

The only apparent object of the use of nitrate of baryta is to produce a slow-burning powder, an end now generally attained by varying the physical characteristics of ordinary powder, notably as regards the size and shape of the grains.

AIX-LA-CHAPELLE POWDER is so-called from the place where it was tried. It consists simply of nitrate of soda and coal dust. (D. p. 609.)

AMIDE POWDER consists of charcoal, saltpetre or its equivalent, and an ammonium salt in such proportions that on ignition a volatile and explosive amide compound is formed.

The proportions given are :—

Saltpetre	...	...	...	101 parts
Nitrate of ammonia	...	...		80 "
Charcoal	...	...	...	40 "

or in the form of a chemical equation :—

$$KNO_3 + H_4N\ (NO_3) + 3\ C = KH_2N + H_2O + CO + 2(CNO_2)$$

The potassamide (KH_2N) is stated to be volatile and explosive at high temperatures and to increase the useful effect of the powder. It is also claimed that very little, if any, residue is left, that no gases injurious to the gun are produced, and that there is much less smoke than with ordinary gunpowder. (Spec. No. 14,412, 24. 11. 85.)

[1] It is stated on the authority of Berthelot that powder made with nitrate of soda is about one-third stronger than when made with saltpetre. (D. p. 605.)

[2] Chiefly obtained from carnallite (KCl, $Mg\ Cl_2\ 6H_2O$), a mineral found in great quantity at Stassfurth in Saxony, lying over beds of rock salt. It resembles the latter in appearance and contains 16 to 18 p.c. of potassium chloride. It is very deliquescent.

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BENNETT'S POWDER consists of the ordinary ingredients of gunpowder, to which a proportion of slaked lime, gypsum, or good cement is added. The mixture is made into a hard paste which is subsequently granulated.

The proportions given are:—

Saltpetre	65 parts
Sulphur	10 „
Charcoal	18 „
Lime	7 „

(D. 600. Spec. No. 3206, 21. 12. 61.)

BLECKMANN'S POWDER (also called HALOXYLINE) consists of sawdust freed from resinous matter or other powdered cellulose substances, saltpetre, and charcoal, with the occasional addition of ferro-cyanate (yellow prussiate) of potash, when a quick explosion is required.

The proportions are:—

Sawdust	9 parts
Charcoal	3 to 5 „
Saltpetre	45 „

The substances are mixed, moistened with one pint of water to about 112 lbs. of the mixture, crushed and ground in a mill, made into cake, and treated like ordinary gunpowder. (Spec. No. 1341, 10. 5. 66.)

BOLTON'S POWDER consists of:—

	Parts.		Parts.
Carbonate of copper	8	Nitrate of soda	350
Graphite	10	Soda ash	20
Prepared quicklime	15	Ferrocyanide of potassium	300
„ alum ...	50	Charcoal	30
„ sugar ...	350	Carbonate of potash ...	450

The carbonate of copper, lime, nitrate of soda, soda-ash, and carbonate of potash are mixed with one half of the graphite and charcoal to form one mixture, the remainder of the ingredients with the remainder of the graphite and charcoal to form another mixture. Each of these is stated to be inexplosive and harmless. When required for use the two mixtures are to be combined. (Spec. No. 342, 31. 1. 68.)

BRADBURY, *see* HARRISON.

BUCKLEY, *see* HARRISON.

BUDENBURG, *see* SCHÄFFER.

CAHUC, *see* SAFETY BLASTING POWDER.

CARBO-AZOTINE, *see* SAFETY BLASTING POWDER.

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COURTEILLE'S POWDER (also called TRIUMPH SAFETY POWDER) consists of the following ingredients:—

Nitrate of soda or of potash ...	60 to 75 parts
Sulphur	10 „ 12 „
Charcoal	7 „ 10 „
Peat and hard coal	9 „ 12 „
"Combined metallic sulphates"...	2 „ 4 „
Oleaginous matter, animal or vegetable (or tar), refined or crude	1 „ 3 „

The mixture is saturated with steam and then heated by superheated steam till nearly dry, the temperature being gradually reduced from 250° F. to 150° F. The powder is then dried on hot plates. The advantages claimed are slow combustion due to the use of peat, charcoal and hard coal, also freedom from explosion in the open, or by friction or percussion. An essential principle claimed is that a comparatively large volume of the ingredients of gunpowder being mixed with a small volume of the other ingredients will under proper conditions, when exploded in a close chamber or under pressure, form nitro-glycerine (!) or an equivalent thereof, and thereby constitute a powerful explosive. This claim appears to be founded on highly doubtful grounds, if indeed on any. (Spec. No. 3217, 14. 9. 75, and T. p. 103.)

CRAIG proposed to use nitrates of lime and magnesia in conjunction with nitrate of soda and to coat each grain of powder with a film of collodion. (D. p. 605.)

DALE, *see* ROBERTS.

DAVEY'S POWDER. In this powder flour, bran, starch, or other glutinous or starchy matter, is employed to replace a portion of the charcoal ordinarily contained in gunpowder. Nitrate of soda may also be substitued for saltpetre, provided that waterproof envelopes are provided for the powder. The object of the invention is to reduce the amount of smoke produced on firing.

The proportions given are:—

	Parts.			Parts.
Saltpetre	64	} or	{ Nitrate of soda	63
Sulphur...	16		{ Sulphur	15
Charcoal	12			
Flour, bran, or starch	8 „			

(Spec. No. 2478, 5. 11. 58.)

DE MERCADER, *see* DE TERRÉ.

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DE TERRÉ'S POWDERS consist of sawdust or similar carbonaceous substance, saltpetre, nitrate of soda, coal dust, lignite dust. He recommends the following proportions:—

For blasting in marble, granite or other hardstone.	Parts.	For blasting in limestone, chalk, coal, or other soft stone.	Parts.
Sawdust	12·5	Sawdust	11
Saltpetre	67·5	Saltpetre	51·5
Sulphur	20·0	Nitrate of soda	16
		Coal or lignite dust	1·5
		Sulphur	20

(Spec. No. 2715, 13. 10. 71.)

DE TRET'S POWDER, known also as PYRONOME, consists of:—

Nitrate of soda	52·5 parts
Spent tan	27·5 „
Sulphur	20·0 „

The ingredients are boiled together and dried. It is a slow-burning powder of no great strength. (Spec. No. 1226, 17. 5. 59.)

DIECKERHOFF'S POWDER (*see* also HERAKLIN) consists of gunpowder mixed with not more than 15 per cent. of precipitated alkaline picrate or picrates, the object being to increase the explosive power of gunpowder without increasing its liability to accident or ignition. It is claimed also that a mixture of nitrate with sulphur and picrate in the above general proportions, without charcoal, is practically equivalent to the above, as experience has shown that charcoal is not essential to the compound. (T. p. 106.)

DIORREXIN, an Austrian explosive consisting of:—

	A	B
Nitrates of potash and soda	75	60
Sulphur	12	12
Sawdust	13	10
Charcoal	—	7
Picric acid	—	1·5
Moisture	—	7·5

(*Mining Journal, 18. 6. 87.*)

EATON'S POWDER, a coarse-grained slow-burning powder containing nitrate of soda. It has been tried in firearms mixed with quicker powder, the object being to obtain a sort of progressive powder. (D. p. 607.)

ESPIR'S POWDER was licensed for manufacture in this country at a factory near Plymouth, but the manufacture has been abandoned, and the amount hitherto consumed has not reached any great proportions. The licence defines it as

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a mechanical mixture of nitrate of soda, sulphur, and sawdust. The specification gives the following composition:—

Nitrate of soda	60 parts
Sulphur	14 „
Sawdust (from hardwoods) ...	26 „

It was made in a wet state, one pint of boiling water being used to dissolve two pints of nitrate of soda. The solution was poured on to and well mixed with the other two ingredients, and the whole dried and sifted. Close confinement is necessary to develope the explosive forces of this powder, it being stated to be quite non-explosive in the open air. It is stated to improve by age. (Spec. No. 291, 26. 1. 75.)

ESSELENS, *see* WYNANTS.

FEHLEISEN, *see* BLECKMANN.

FORTIS EXPLOSIVE, *see* GLYCERO-NITRE.

FREIBERG POWDER consists of:—

Nitrate of soda	61·66 parts
Sulphur	17·25 „
Charcoal	17·35 „

(D. p. 609).

GACON'S POWDER consists of 69 parts of potassium or sodium nitrate and 19 parts sulphur. The ashes of dead leaves are added, and finally a solution of tannin in water. It is said to require a temperature of 900° F. to ignite it, and to be absolutely insensible to percussion. (M., No. X., p. 196.)

GALLAHER'S POWDER consists of:—

Nitrate of soda, or „ potash	70	to 80	parts.
Sulphur	6	to 12	„
Sulphate of iron ...	1	to 3	„
Charcoal	8	to 16	„
Sulphate of copper	0·5	to 1	„
Ground bark ...	8	to 14	„

It is claimed to be safer than ordinary blasting powder and not to be liable to ignition by friction or percussion. (T. p. 106.)

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GLYCERO-NITRE proposed by Heusschen consists of:—

	1	2	3	4	5	6	7	8	9
Nitrate of Potash	65·01	66·02	67·03	68·04	69·05	70·06	72·08	74·10	93·19
Sulphur	12·00	12·00	12·00	12·00	12·00	12·00	12·00	12·00	12·00
Lampblack ...	3·00	3·00	3·00	3·00	3·00	3·00	3·00	3·00	3·00
Tan	20·00	20·00	20·00	20·00	20·00	20·00	20·00	20·00	25·00
Sulphate of Iron	1·39	2·78	4·17	5·56	6·95	8·34	11·12	13·90	27·80
Glycerine	0·92	0·92	0·92	0·92	0·92	0·92	0·92	0·92	1·84
	102·32	104·72	107·12	109·52	111·92	114·32	119·12	123·92	162·83

The first five materials are powdered, wetted, and evaporated nearly to dryness. It is then completely dried, cooled, and the glycerine added to it. It is a black powder. It is claimed that various forms of nitro-glycerine are produced in the act of explosion in a blast-hole. (Spec. No. 1024, 8. 1. 84.) The mixture and the advantages claimed are much the same as in the case of *Courteille's Powder q.v.*

This explosive has been submitted for authorisation in this country under the name of "Fortis" and it has been intimated that, subject to certain conditions, licenses will be granted for it.

GRENADINE, *see* GACON.

HALOXYLINE, *see* BLECKMANN.

HARRISON'S POWDER consists of:—

Saccharum (saccharine matter)	...	50 parts
Saltpetre		48 ,,
Club moss (lycopodium clavatum)		2 ,,

(Spec. No. 1786, 24. 7. 60.)

For other powders proposed by Harrison, *see* Chlorate mixtures.

HERAKLIN consists of picric acid, nitrates of potash and soda, sulphur, and sawdust (of oak or other hard wood). It is manufactured as follows:—In 36 parts of boiling water ½ a part each of picric acid and saltpetre are dissolved and 15 parts of sawdust are impregnated with this solution. The impregnated sawdust is dried, and to every 10 parts thereof are added 17·5 parts each of nitrates of potash and soda, and 7·5 parts of sulphur. All the ingredients are finely powdered. Compressed sticks or bars of the same material are made by treating the material throughout in a damp state. (Spec. No. 4155, 1. 12. 75.)

HEUSSCHEN, *see* GLYCERO-NITRE.

HIMLY proposed a gunpowder in which hydrocarbons precipitated from solutions in naphtha take the place of the charcoal and sulphur of ordinary powder. The powder so made is said to be quite waterproof. (M., No. IV., p. 298.)

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JOHNITE consists of:—

Nitrate of potash	75 parts
Sulphur	10 „
Lignite	10 „
Picrate of soda	3 „
Chlorate of potash	2 „

(*Mining Journal, 18. 6. 87.*)

KÜP'S POWDER contains 80 per cent. of nitrate of baryta with sulphur and charcoal.

LE BRICQUIR, *see* ESPIR.

LIESCH'S POWDER consists of saltpetre and coke dust.

LITHOFRACTEUR (nitrate mixture) *see* SAXIFRAGINE.

LLOYD, *see* GALLAHER.

LOBB'S POWDER. In this powder sawdust is substituted for charcoal and sulphur in gunpowder and lime is added. The object of the sawdust is to reduce the amount of smoke. The lime is added to counteract the deliquescent property of nitrates of soda or potash in gunpowder especially in underground or damp situations. (Spec. No. 1861, 25. 10. 61.)

MATTEHN, *see* PYROLITHE.

MILLER'S POWDER consists of two compounds which are harmless apart and become explosive only when mixed.

No. 1 compound contains:—

Nitrate of soda	35 parts
Saltpetre	25 „
Starch	2 „

No. 2 compound contains:—

Bichromate of potash	3 parts
Sulphur	13 „
Charcoal	12 „

The proportions to form an explosive compound are 18 parts of No. 1 mixed with 7 parts of No. 2 (T. p. 106).

MURTINEDDU'S POWDERS consist of mixtures of nitrate of soda (with or without saltpetre) with sulphur and various substances as tan, coal, sawdust, &c.

The mixture, patented in England, consists of:—

Saltpetre	100 parts
Sulphur	100 „
Sawdust...	50 „
Horsedung	50 „
Sea salt	10 „
Treacle	4 „

The object of adding the treacle is to give cohesion to the composition. It is claimed that "this composition does not cause explosion upwards as with gunpowder" (D. p. 608, and Spec. No. 2403, 14. 10. 56.)

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NEWTON, *see* SAXIFRAGINE.

NOBEL proposed a gunpowder for propelling purposes composed of 80 parts saltpetre, 6 parts or less of sulphur, and 14 parts of charcoal. To this was to be added, when desirable, to quicken its action (*a*) ordinary gunpowder, or (*b*) compressed guncotton or (*c*) equal parts of nitrate of potash and picrate of ammonia with the addition of a little gum. For blasting purposes the foundation was ordinary blasting powder or that made with nitrate of soda, while the quickening agents were (*a*) equal parts of picrate of lead or potash and saltpetre with a little gum, or (*b*) gelatinised nitro-glycerine or other known nitro-glycerine compound or (*c*) compressed guncotton. He expressly bars the use of chlorate of potash powders as being too dangerous. (Spec. No. 226, 20. 1. 79.)

OLIVER proposed to use peat in lieu of charcoal in gunpowder, and occasionally chlorate of potash mixed with beeswax or tallow and resin in lieu of sulphur. In this case the ingredients were to be mixed in a damp state. (Spec. No. 1800, 10. 6. 69.)

ORIENTAL POWDER consists of a mixture of tan, bark, sawdust or other vegetable fibre, impregnated with a nitrate or chlorate and gunpowder or similar explosive compound. Spent tan is preferred (T. p. 100.)

OXLAND'S POWDER consists of:—

Nitrate of soda	85 parts
Sulphur	16 „
Charcoal	18 „
Coal or dust *(sic)*	20 „

The nitrate of soda is refined from the crude salt by precipitating the salts of lime and magnesia by carbonate of soda and evaporating the filtered solution. (Spec. No. 1740, 18. 7. 60.)

PERALITE is a large grained powder consisting of:—

Saltpetre	63 parts
Charcoal	30 „
Sulphide of antimony	6 „

POCH, *see* PUDROLITHE.

PUDROLITHE or ROCK POWDER consists of:—

Saltpetre	68 parts			
Sulphur	12 „	or	Sulphur	8 parts
			Powdered gumlac	3 „
Charcoal	6 „			
Nitrate of baryta	3 „			
„ soda ...	3 „			
Sawdust	5 „			
Spent tan	3 „			

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The nitrates of soda and baryta are dissolved in hot water and the tan and sawdust added to the solution and boiled until dry. The other ingredients are then added and the whole mixed together. The compound claims to be slow-burning and to give but little smoke.

The manufacture of this explosive was carried on at a factory near Llangollen, but was abandoned a few years ago. (Spec. No. 656, 2. 3. 72.)

PYROLITHE consists of:—

Saltpetre	51·5 parts
Nitrate of soda	16·0 „
Sulphur	20·0 „
Sawdust	11·0 „
Charcoal	1·5 „

The inventor (Matteen) also patented another mixture consisting of:—

Nitrate of soda	47 parts
Saltpetre	18 „
Sulphur...	17 „
Sawdust	12 „
Carbonate or sulphate of soda	6 „

The idea is to have no carbonic oxide in the products of combustion. (D. p. 106.)

PYRONOME, *see* DE TRET, also a *chlorate mixture* under same name, p. 569.

PYRONITRINE was submitted to the French Government Commission in 1884 by M. Prodhomme. There were two samples of the following compositions:—

	1	2
Nitrate of soda	35	18
Saltpetre...	35	45
Tan...	15	15
"Sulphate"	2	3
Sulphur	6	9
Charcoal	3	—
Resin	4	3
Tar	—	7

ROBERT'S POWDER. In this powder nitrate of soda is used wholly or partially in place of saltpetre in gunpowder. A proportion of anhydrous sulphate of soda (prepared by heating sulphate of soda) or of anhydrous sulphate of magnesia, not exceeding 18 per cent. of the nitrate of soda, is used therewith. (Spec. No. 139, 18. 1. 62.)

ROCK POWDER, *see* PUDROLITHE.

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SAFETY BLASTING POWDER (called also CARBO-AZOTINE) is licensed for manufacture in this country by Messrs. Pigou, Wilks, and Laurence, (Ld.) In the license it is defined as a mechanical mixture of saltpetre, sulphur, lamp black, sawdust, and sulphate of iron. In the specification it is defined as consisting of:—

Nitrate of potash „ soda „ lime	one, two or three nitrates	in all	50 to 64 parts
Sulphur			13 to 16 „
Tanner's bark (that containing animal matter is preferred) or ... ... Sawdust, or ... ... Bark and sawdust			14 to 16 „
Soot or lampblack, or both			9 to 18 „

and 5 to 6 parts of sulphate of iron to every 100 parts of the above mixture.

The materials are ground and boiled in a weak solution of sulphate of iron. The compound becomes liquid and then generally solidifies. When nearly solid it is dried.

This powder is issued occasionally in bulk but more usually in the form of compressed cartridges like those made of gunpowder. It requires compression and confinement before it will explode.

It is recommended to be used as a wash, with about 10 gallons of water to 2 lbs. of the compound, as a remedy for *phylloxera vastatrix*. (Spec. No. 3934, 14. 11. 74.)

In 1877 CAHUC took out a fresh patent for an improvement on his original powder as described above. He gave the following proportions as the best for blasting in various materials:—

	Hard rock.	Less hard rock and coal.	Bituminous coal and gypsum.
Saltpetre	70	64	56
Sulphur	12	13	14
Lamp black ...	5	4	3
Spent tan or Sawdust ...	13	19	27
Sulphate of iron	2	2	5

He claims that these powders are equally powerful with those previously proposed and safer to manufacture and use. (Spec. No. 4732, 12. 12. 77.)

SAXIFRAGINE consists of:—

Nitrate of baryta	77 parts
Charcoal	21 „
Saltpetre	2 „

The nitrate of baryta is prepared by treating the chlorate of barium with nitrate of soda. The manufacture is identical with that of gunpowder. To increase the inflammability of the powder the grains while still damp are dusted over with meal powder. (D. p. 610.)

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SCHÄFFER'S POWDERS consist of:—

Saltpetre	30 to 38 parts
Nitrate of soda	40 „
Sulphur	8 to 12 „
Charcoal	7 to 8 „
Potassio-tartrate of soda (Rochelle salt, $K Na C_4 H_4 O_6$) ...	4 to 6 „

It is a slow burning powder. (Spec. No. 2555, 19. 10. 63.)

A subsequent specification gives:—

Potassio-tartrate of soda ...	4 parts
Saltpetre	78 „
Sulphur...	8 „
Charcoal	10 „

SOULAGES, *see* SAFETY BLASTING POWDER.

TRIUMPH SAFETY POWDER, *see* COURTEILLE'S POWDER.

VIOLETTE'S POWDER consists of:—

Nitrate of soda	62·5 parts
Acetate	37·5 „

The ingredients can be melted together so as to give a close combination, but if heated to about 660° F. the mixture explodes. It is hygroscopic. (B. II., p. 315.)

WALKER, *see* GALLAHER.

WINDSOR'S POWDER consists of 25 parts of dry powdered sugar added to 100 parts of gunpowder. (Spec. No. 3510, 4. 12. 11.)

WYNANT'S POWDER. In this powder nitrate of baryta wholly or partially replaces the saltpetre in gunpowder. The following proportions are recommended:—

Nitrate of baryta	77 parts
Charcoal	21 „
Saltpetre	2 „

(This is identical with Saxifragine).

The nitrates of lead or strontia may replace the nitrate of baryta. The inflammability of the powder may be increased by dusting or coating the grains with ordinary fine powder. (Spec. No. 1084, 15. 4. 62.)

Experiments were made at Brussels with a powder in which ⅓ of the saltpetre in gunpowder were replaced by nitrate of baryta. It was found to be unfit for small-arms on account of its slowness of combustion, and for larger arms on account of its fouling. It was consequently relegated to the rank of a blasting powder only. (D. p. 610.)

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XANTHINE POWDER consists of a mixture in which the sulphur and charcoal of ordinary powder are replaced by a compound containing them both, *e.g.* xanthate of potash, (C_2 H_5 KCO S_2) a compound prepared by adding to absolute alcohol an excess of pure caustic potash and of bisulphide of carbon. The proportion is :—

Saltpetre	100 parts	
Xanthate	40 „	
Charcoal...	6 „	(B. II., p. 315)

CLASS III.—(CHLORATE MIXTURES).

The employment of chlorate of potash in explosive mixtures has always offered great attractions, owing to the violence of its effects due to the rapidity of its action. Hence the number of proposed explosives in which this substance forms the main ingredient is extremely large, as will be seen on referring to the alphabetical list of them. At the same time they may, broadly speaking, be divided into two classes, those in which no particular attempt is made to diminish the dangerous sensibility of chlorate of potash compounds, and those in which by the addition of some diluting ingredient or by some special mechanical treatment, endeavours are made to diminish this sensibility. Some of the compounds in the list appear to be simply more or less dangerous hap-hazard mixtures, while in other cases the same mixture of ingredients or the same method of treatment has with little, if any, variation, been proposed over and over again under different names. The objections to chlorate of potash compounds have been stated by several authorities.

For instance, Dr. Duprè, F.R.S., whose knowledge of explosives is exceptional in extent and minuteness, says :—"Chlorate of potassium "on account of the readiness with which it lends itself to the produc- "tion of powerful explosives offers a great temptation to inventors of "new explosives, and many attempts have been made to put it to "practical use, but so far with very limited success. This is chiefly "owing to two causes. In the first place chlorate of potassium is a "very unstable compound,[1] and is liable to suffer decomposition "under a variety of circumstances, and under, comparatively speaking, "slight causes, chemical and mechanical. All chlorate mixtures are "liable to what is termed spontaneous ignition, or explosion in the "presence of a variety of materials, more particularly of such as are "acid or are liable to generate acid; and all chlorate mixtures are readily "exploded by percussion, but more particularly by combined friction "and percussion, such as a glancing blow which might easily and "would often occur in charging a hole. In the second place there is "some evidence to show that this sensitiveness to percussion and

[1] "Chlorate of potassium is one of those compounds during the decomposition of which heat is "evolved, or energy is produced during decomposition, instead of, as is usually the case, being "absorbed, and all such compounds are unstable."

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"friction increases by keeping, more especially if the explosive is "exposed to the action of moist and dry air alternatively."[1]

The glancing blow referred to by Dr. Duprè is such as can be given with a slanting blow with a hammer on a plane or curved surface. Many chlorate mixtures which have been proposed for general use were found on trial to be so sensitive that they could be readily exploded by blows of this description with a light wooden mallet on a wooden floor, and almost all could be exploded with the same mallet on a stone floor.[2] The increased sensitiveness caused by keeping and exposure to moisture is probably due, in part at least, to the chlorate crystallizing out into fine crystals on the surface of the mixture.

Eissler, on the same subject, after referring to the fatal accident that attended the efforts of the discoverer of chlorate of potash, Berthollet, to utilize it in the manufacture of gunpowder, goes on to say :—"It is "extremely doubtful from the peculiarities of this salt, if anybody will "ever overcome the obstacles due to its inherent chemical properties, "which nature manifestly seems to have made unconquerable. In "mixing these compositions great danger is attendant, and too much "circumspection cannot be used. Thy explode instantly on any violent "stroke, very often by friction alone; sometimes spontaneously as "when in a state of rest, and no known cause for their combustion "can be ascertained. Many are deluded as to its safety by so-called "experiments with freshly made powder. Manufacturers of the com- "pound may attempt to show its safety by hammering and cutting it "and similar tests; but let the powder be exposed to the natural "atmospheric action, attract some moisture during the damp foggy "night, then get dry, and the least friction or blow will cause an "unexpected explosion. . . . . In ramming a cartridge well home "in a bore-hole the unsuspecting miner must either use blows or "pressure, the latter being equally dangerous from the development "of some friction. . . . ."[3]

Berthelot[4] remarks : "Les poudres au chlorate n'offrent donc pas à "ce point de vue (strength) sur les nouvelles matières explosives une "prepondérance qui puisse compenser les dangers exceptionnels de leur "fabrication et de leur manipulation. Ce n'est que comme amorces "que leur facile inflammation peut offrir certains avantages."

Without going so far as to say that it is impossible to manufacture a safe chlorate mixture, it is a fact that out of many which have been examined with a view to their introduction into this country, not one has as yet been found to be safe enough to be licensed with the exception of asphaline[5], but this explosive was not a practical success inasmuch as its light and bulky nature required very large bore-holes

[1] Annual Report of H.M. Inspectors of Explosives for 1885, p. 31.
[2] This practically reproduces the conditions of a wooden rammer in a stone bore-hole.
[3] Eissler, p. 139.
[4] B., Vol. II., p. 825.
[5] *See* p. 561.

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in comparison with other explosives, and its manufacture and use in this country has been entirely abandoned.

Probably also the explosive papers such as *Melland's Paper Powder* and *Reichen's Rolls*[1] are fairly safe, but they have never to my knowledge come into practical use here, and the same objection of bulkiness in proportion to weight holds good with them as with asphaline.

I do not pretend to say that powerful and valuable explosives may not be, and have not been, manufactured with chlorate of potash as their main ingredient, but I contend that though these are fairly safe when used for special purposes and by experts, none have as yet been brought to notice (with the previously named exception) which are suitable for general use by the mining population, and which could be relied upon not to cause accidents under ordinary conditions of transport, storage, and use.

In some cases it has been proposed to keep the ingredients of chlorate of potash mixtures apart till required for use, and this principle has been carried out in the case of Rack-a-rock and other explosives, but this class will be more particularly dealt with in Class VII. (Sprengel Explosives) though some of them will be found also included in the list of the chlorate mixture class.

ASPHALINE consists of thoroughly cleansed wheat or barley bran impregnated with chlorate of potash (in a proportion not exceeding 54 parts of chlorate to 42 parts of bran) mixed with saltpetre and sulphate of potash (in a proportion not exceeding 4 parts to 42 parts of bran). Paraffin oil, paraffin, ozokerit, and soap, or some of them may be added. The compound is coloured pink with fuchsine.

A variety of the above is called ASPHALINE No. 2 and consists of the above with the addition of saltpetre in such proportion that the total amount of saltpetre present in the explosive does not exceed 25 per cent. These explosives were licensed for manufacture in a factory near Llangollen, previously used for the manufacture of Pudrolithe, but the manufacture has been abandoned.

The explosive is easily recognised by its bulkiness and resemblance to red or pink bran.

AUGENDRE'S POWDER known also as WHITE GERMAN or AMERICAN POWDER consists of:—

Chlorate of potash	... ...	50 parts
Yellow prussiate of potash	...	25 ,,
Cane sugar	... ...	25 ,,

The materials are moistened, mixed in bronze mortars, and granulated. (D. p. 614.)

BARON and CAUVET submitted to the French Government Commission in 1882 two powders consisting of:—

	No. 1.	No. 2.
Chlorate of potash	50 ...	50
Prussiate...	50 ...	25
Sugar	— ...	25

They are simply varieties of Augendre's powder.

[1] *See* pp. 567 and 570.

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BELLFORD'S POWDER consists of:—

Charcoal	19·5 parts
Saltpetre	68·0 ,,
Sulphur	12·5 ,,

mixed, pressed, and granulated. The powder so produced is saturated with a saturated aqueous solution of chlorate of potash, dried at 100° F. for four days, and used unglazed. (Spec. No. 2910, 15. 12. 53.)

BRADBURY, *see* HARRISON.

BUCKLEY, *see* HARRISON.

CALLOW, *see* MELVILLE.

CHANU, *see* DAVEY.

CLEMENT, *see* FUCHS.

COTTER'S POWDER contains about equal parts of chlorate of potash and realgar.

DAVEY'S POWDERS consist of:—

	1	2
Chlorate of potash	6 parts	6 parts
Nitrate	5 ,,	3 ,,
Yellow prussiate	2 ,,	4 ,,
Bichromate	2 ,,	— ,,
Sulphide of antimony ...	5 ,,	3 ,,

These compounds are chiefly intended for use as fuzes. (Spec. No. 14,065, 15. 4. 52.)

DAVIES POWDER consists of:—

Yellow prussiate of potash ...	4 parts
Chloride of potassium	8 ,,
Loaf sugar	2 ,,
Crystallized sugar	2 ,,
Sulphur	1 ,,

It was proposed as a powder for firearms. The ingredients were to be mixed together when fired, being previously finely powdered. (Spec. No. 824, 30. 3. 60).

DYNAMOGEN consists of:—

Yellow prussiate of potash ...	17 parts
Water	150 ,,
Charcoal	17 ,,

These are boiled, well stirred, and allowed to cool

There are then added:—

Potash	35 parts
Chlorate of potash	70 ,,
Starch	10 ,,
Water	50 ,,

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The whole is made into a thin paste and brushed on to filtering paper, three coats being laid on each side. The paper so impregnated is dried, cut up, and rolled into cartridges. (M. No. VII., p. 115.)

EHRHARDT'S POWDERS consist of :—

	For Artillery.	For Blasting.	For Shells.
Chlorate of potash	1 part	1 part	1 part
Saltpetre	1 „	1 „	— „
Charcoal	— „	4 „	— „
Tannic acid	1 „	2 „	1 „

(D. p. 613.)

He also proposed a mixture of about equal parts of tannic acid or resin and chlorate or nitrate of potash finely powdered. (Spec. No. 1694, 8. 7. 64.)

Also a mixture of the same ingredients in the proportion of one to three. The powders were to be placed in a flask with two chambers and so kept separate till mixed in the act of loading. Spec. No. 2594, 20. 10. 64.)

Also a mixture of :—

	For Blasting.	For Arms.
Chlorate of potash	1·5 parts (by bulk)	4 parts (by weight)
Nitrate of „	1·5 „ „	— „
Cutch or tannin	1·0 „ „	1 „
Cannel coal	2·0 „ „	— „

(Spec. No. 402, 13. 2. 65.)

ETNITE practically consists of ASPHALINE with the addition of about 8 per cent. of sulphide of antimony.

EXPLOSIVE PAPER is much the same as DYNAMOGEN and other similar explosives, consisting of rolls of paper impregnated with a chlorate mixture. The ingredients in this case are :—

Saltpetre	5 parts
Chlorate of potash	5 „
Charcoal or Powdered coal	1 „
Fine hardwood sawdust	1 „

with a little gum for binding, and enough water to make a paste. (M. No. VII., p. 115.)

FENTON'S POWDER consists of chlorate of potash, sugar, and yellow prussiate of potash in the proportions of four to eight ozs. of each of the latter ingredients to 16 ozs. of damp chlorate. The mixture is made in the form of a stiff dough, being damped with lime water, gum water, or water. It is dried in an oven, cut up with brass knives, and sifted into various sizes of grains. The powder can be coloured with various colouring matters, which it is apparently proposed also to use in lieu of sugar. It is claimed as suitable for all kinds of small arms and ordnance and for blasting purposes. (Spec. No. 4148, 17. 12. 73.)

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FLÉRON DE, *see* PERTUISET.

FRENCH GREEN POWDER consists of:—

Chlorate of potash	14 parts
Picric acid	4 „
Yellow prussiate of potash ...	3 „

Each ingredient is separately dried and finely powdered, and the mixture is made in glass vessels, or preferably in wooden vats with wooden balls. (R.A.I. Proc., Feb. 1887.)

FUCH'S POWDER consists of a mixture of chlorate of potash, finely ground tortoise or turtle shell, saltpetre, sulphur, and charcoal. (T. p. 101.)

GARSIDE, *see* HARRISON.

GOETZ' POWDER is a mixture of an explosive base with glucose (grape sugar $C_6H_{12}O_6$), uncrystallizable sugar, or syrupy solution to prevent premature or accidental discharges. The proportions recommended are:—

Chlorate of potash...	10 parts
Solution of glucose	10 „
Charcoal in powder	3 „
Sulphur...	2 „
Amorphous phosphorus ...	1 „
Picrate of lead	3 „

It is claimed that the compound will stand all ordinary shocks, handling, and transport, without danger of explosion. It burns with a bright light when unconfined. (T. p. 105.)

GOMEZ' POWDERS are mixtures of chlorate and prussiate of potash with sugar (acetate) of lead, or nitrate of lead, or sugar of lead and nitrate of iron. (T. p. 101.)

GRAHAM'S POWDER consists of:—

Yellow prussiate of potash ... 16	parts
Chlorate 40	„
White sugar 20	„
Red lead ... ... 1·25	„

It is claimed that the red lead obviates the danger of explosion, and that the compound can be used when wet and doughy. (T. p. 106.)

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HAFENEGGER'S POWDERS consist of the following compounds:—

	No. 1. parts.	No. 2. parts.	No. 3. parts.	No. 4. parts.	No. 5. parts.	No. 6. parts.	No. 7. parts.
Chlorate of potash	9 or 6	2	4	4	1	11	1
Sulphur	¼ „ 1	—	1 (or sugar)	¼	—	¼	—
Charcoal	¼ „ 4	—	¼	¼	—	¼	1
Yellow prussiate of potash	—	1	1	—	—	—	—
Sugar	—	1	1 (or sulphur)	4	1	—	—

He recommends for use with the above a self-igniting liquid consisting of solution of one or two parts of phosphorus in two parts of bisulphide of carbon, the time before explosion takes place being regulated by the amount of saturation of the powder with the liquid, the average period being about half-an-hour. He also proposes simply a mixture of chlorate of potash with the liquid. (Spec. No. 2865, 17. 9. 68.)

The danger and uncertainty of the propositions are obvious.

HAHN'S POWDER consists of:—

Chlorate of potash	367·5 parts
Tersulphide of antimony ...	168·3 „
Spermaceti	46·0 „
Charcoal	18·0 „

The idea is to add the chlorate of potash only when required for use, the mixing being done by sieves. The addition of the spermaceti is claimed to give safety against explosion by friction. (Spec. No. 960, 30. 3. 67.)

HALL'S POWDER consists of:—

Chlorate of potash	47 parts	
Ferrocyanite of potassium ...	38 „	
Sulphur (or other chemical equivalent)	5 „	(about)

The ingredients are pulverized and mixed in water, or "water and nitric acid." To the evaporated mixture are added 10 parts of caoutchouc, sometimes slightly impregnated with bisulphide of carbon. The whole is mixed, pressed, and granulated. (Spec. No. 1062, 28. 4. 63.)

HARRISON'S POWDERS consist of mixtures of saccharine matter with carbon sulphur, clubmoss, and chlorate of potash. The following proportions are given:—

Chlorate of potash	7 parts, or for rifle shooting					...	11 parts
Starch	1 „	„	„	„	„	...	1 „
Charcoal	1 „	„	„	„	„	...	1 „
Sulphur	1 „	„	„	„	„	...	2 „
Clubmoss (lycopodium clavatum)	— „	„	„	„	„	...	¼ „
Coal	— „	„	„	„	„	...	1 „
Soot from coal	— „	„	„	„	„	...	½ „

(Spec. No. 2642, 29. 10. 60.)

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Subsequent specifications give :—

Chlorate of potash ..	56 parts...	... 12 parts	(or chlorate of soda)
Ferrocyanide of potash	28 „ ...	... 4 „	
Starch	4 „ ...	... 2 „	
Sulphur	7 „ ...	... — „	
Charcoal	5 „ ...	... 1 „	
Nitrate of potash		... 6 „	

(or 2½ parts of coal or cannel).

(Spec. Nos. 2233, 6. 9. 61, and 305, 5. 2. 62.)

HOCHSTÄTTER'S COMPOUND consists of a mixture of chlorate of potash or of lead, nitrate of potash, or of soda, and charcoal or sulphur or a metallic sulphide. The mixture is dissolved in water in which paper or vegetable matters are steeped so as to render them explosive. (Spec. No. 2869, 17. 12. 69.)

HORSLEY'S POWDER consists of a mixture of finely powdered chlorate of potash and gall nuts in the proportions of three to one. The powder is granulated by passing it through a sieve in a damp state. It is stated to explode at 430° F. and its force to be "five times that of gunpowder." (Spec. No. 1193, 19. 4. 69, and No. 1885, 22. 6. 72.)—*See* also Class IV.

JALINE consists of:—

Nitrate of potash... ...	65 to 75	parts
Sulphur	10	„
Lignite	10 to 50	„
Picrate of soda	3 to 8	„
Chlorate of potash ...	2	„

JOLLY, *see* WIGFALL.

KELLOW'S POWDERS consist of:—

Nitrate of soda	30 parts	or 36	parts.
„ potash	8 „	„ 4	„
Chlorate of potash	12 „	„ 6	„
Sulphur	10 „	„ 10	„
Tan and sawdust...	46 „	„ 50	„

To each of the above receipts 30 quarts of water are added and the compound mixed, dried and sifted. The proportions may be varied, greater strength being given by increasing the amount of chlorate of potash and diminishing that of the nitrate of soda. (Spec. No. 1796, 17. 6. 62.)

KNAFFL'S POWDER consists of:—

Chlorate of potash...	46	parts
Nitrate of potash	26	„
Sulphur	15	„
Ulmate of ammonia	10	„

Ulmate of ammonia is a brown matter obtained by exposing a mixed cotton and wool fabric to the action of

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superheated steam. The cotton is untouched but the wool forms a brown matter easily removed by a beating machine. It is usually sold for manure.

As might be expected from its composition the above powder is very sensitive. (D. p. 612.)

KÖHLER'S POWDER consists of :—

Chlorate of potash...	70 parts
Sulphur...	20 ,,
Charcoal	10 ,,

Obviously a dangerously sensitive powder.

(Spec. No. 1622, 10. 6. 57.)

MACINTOSH proposed to mix gunpowder and other explosive compounds with india-rubber or gutta-percha in a state of solution and to spread the mixture on cloth, which becomes inflammable, burning rapidly if mixed with chlorate or nitrate of potash, and slowly if mixed with steel filings or sulphur. The cloth can be cut into strips and used in connection with incendiary projectiles. (Spec. No. 404, 11. 2. 57.)

MELLAND'S PAPER POWDER consists of unsized paper dipped into a boiling solution of the ingredients given below. The paper is then rolled into cartridges and dried at 212° F. To protect the cartridges from damp they are coated with a solution of one part of xyloidine (nitro-starch) in three parts of acetic acid. The ingredients are as follows :—

Chlorate of potash...	9 parts
Nitrate of ,, ...	4·5 ,,
Ferrocyanide of potash... ...	3·25 ,,
Charcoal of potash	3·25 ,,
Starch	$\frac{1}{21}$,,
Chromate of potash	$\frac{1}{16}$,,

(D. p. 614.)

This was patented in England by REICHEN. (Spec. No. 2266, 2. 9. 65.)

MELVILLE'S POWDERS consist of :—

	1	2	3
Chlorate of potash ...	2 parts	5 parts	1 part
Red orpiment	1 ,,	2 ,,	— ,,
Prussiate of potash ...	— ,,	1 ,,	1 ,,

The ingredients are well mixed, damped, and moulded into cartridges for fire-arms or for mining purposes, or charging shells. (Spec. No. 13,215, 6. 10. 50.)

MONNIER'S POWDER consists of :—

Chlorate of potash...	71 parts
Sugar	16 ,,
Charcoal	6 ,,
Coal tar...	7 ,,

The chlorate is dissolved in 250 parts water, and freedom from danger is claimed for the wet process of manufacture. (T. 106.)

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MUNDELL, *see* PERTUISET.

NISSER'S POWDERS consist of:—

Yellow prussiate of potash	1·5
Bichromate „ „	2·0
Perchlorate or chlorate of potash ...	10·5
Nitrates of soda and potash	44·5
Vegetable matter	6·5
Mineral and vegetable carbon ...	19·5
Sulphur	15.5

A more explosive powder for ordnance and firearms is made by using more of the potassium salts and less carbon and sulphur. (Spec. No. 1939, 26. 7. 65.)

He also proposed two inexplosive compounds to be kept apart till required for use when their mixture formed an explosive.

No. 1 compound consisted of nitrate of potash or of soda mixed with perchlorate or chlorate of potash, or both, in proportions varying from 5 to 35 per cent. of each of these salts according to the required strength of the powder.

No. 2 compound consisted of 25 to 35 per cent. of pure loaf sugar added to sublimed sulphur, and to these 8 to 10 per cent. of vegetable fibre or charcoal or both.

The powder is stated not to ignite by friction or percussion. (Spec. No. 1375, 27. 4. 68.)

He also proposed two compounds, consisting of chlorate of potash 55 to 60 parts, bitartrate of potash 45 to 55 parts, ferrocyanide of potash, and coal. In the second compound the ferrocyanide of potash was replaced by sulphur. (Spec. No. 119, 14. 1. 70.)

NOBLE'S POWDERS were submitted to the French Government Commission in 1880. Of these there were eight samples of the following compositions:—

	1	2	3	4	5	6	7	8
Chlorate of potash ...	100	100	100	50	100	100	100	100
Sugar	20	22	24	20	20	20	10	15
Prussiate of potash...	16	18	22	8	—	8	16	16
Starch	1	—	—	2	2	2	2	1
Camphor...	2	—	—	2	2	2	2	1
Sulphur	—	—	—	8	—	—	—	—
Benzoin	—	—	—	—	16	8	—	—
Saltpetre...	—	—	—	—	—	—	50	50
Charcoal	—	—	—	—	—	—	10	5

As might be expected they were dangerously sensitive. The addition of the camphor did not have the effect in diminishing the sensitiveness of the compounds containing it which it has in the case of guncotton and nitro-glycerine compounds.

PAINE, *see* DAVIES.

PATTISON mixes chlorate of potash explosives with greasy vegetable flour or bran to lessen liability to explode. (T. p. 106.)

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PELEY'S EXPLOSIVE PAPER consists of ordinary blotting paper soaked in the following mixture :—

Chlorate of potash...	66 parts
Yellow prussiate of potash ...	17 „
Refined salt	35 „
Wood charcoal	17 „
Starch	10 „

the whole being mixed with 10 times its weight of boiling water. The paper is dried, cut into strips, and rolled into cartridges. (R.A.I. Proc., Feb. 1886.)

PELLIER'S POWDER was submitted to the French Government Commission in 1884. It consists of :—

Chlorate of potash	100 parts
Saltpetre	12½ „
Sulphur	12½ „
Fine sawdust	9 „
Extract of logwood	15 „

It is practically the same as Kellow & Short's powder. The same inventor had previously, in 1882, submitted to the same Commission two similar powders composed as follows :—

	For blasting.	For guns.
Chlorate of potash... ...	44 to 47	40
Yellow prussiate of potash	38 „ 36	15
Flowers of sulphur ...	18 „ 17	10
Sugar	—	10
Charcoal	—	5
Saltpetre	—	15

Both were of course extremely sensitive.

PERTUISET'S POWDER consists of :—

Chlorate of potash	2 parts
Sulphur	1 „
Sporting gunpowder	⅛ „
Animal charcoal	1/30 „

It is recommended for use mainly as a detonating powder, or for filling bullets or shells. (Spec. No. 2837, 9. 10. 67, and No. 2066, 21. 7. 70.)

PETRY, *see* DYNAMOGEN.

POHL'S POWDER is almost identical with Augendre's. It consists of :—

Chlorate of potash...	49 parts
Yellow prussiate of potash ...	28 „
Cane sugar	23 „

(D. 615.)

PRUSSIAN FIRE, *see* WIGFALL.

PYRONOME consists of :—

Saltpetre	69 parts
Sulphur...	9 „
Charcoal	10 „
Metallic antimony...	8 „
Chlorate of potash...	5 „
Rye flour	4 „

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together with small quantity (a few centigrams) of chlorate of potash. The ingredients are boiled together, the mass evaporated down to a paste, dried, and powdered. (M.V. p. 751).

RACKAROCK consists of compressed cartridges made of chlorate of potash which are dipped when required for use into certain liquids which are by themselves like the chlorate of potash of an inexplosive character. The liquids are "dead oil," a dark heavy oil consisting chiefly of hydro-carbons derived from coal tar and having a high boiling point, or a mixture of dead oil with its own volume of bisulphide of carbon, or a mixture like the last with the addition of about 3 per cent. of sulphur.

The chlorate of potash cartridges are enclosed in small bags of cotton or other cloth of suitable size and shape and dipped into the liquid. Preferably the mixture of dead oil and bisulphide of carbon is used, the object of the bisulphide of carbon being to prevent too large a proportion of dead oil from being taken up by the chlorate. The bisulphide afterwards evaporates out.

Nitro-benzol is also used as a dipping liquid, or as an ingredient thereof in combination with picric acid.

In practice the cartridges in a wire basket are suspended from a spring balance and dipped into a pail containing the fluid. The completion of the absorption of the proper amount of fluid is shown by the spring balance. The proportions given are 3 to 4½ parts solid to 1 part liquid ingredient. See also "Sprengel Explosives," p. .

RAVES' POWDER is mixture of chlorate of potash and charcoal, or wood dust, or coal. The ingredients are made into a paste, dried and ground. The average proportions are given as 100 parts of vegetable matter or carbon to 200 parts of chlorate of potash. (Spec. No. 2651, 23. 11. 59.)

REICHEN patented some rolls or cartridges of paper impregnated with a chlorate mixture identical with MELLAND'S PAPER POWDER. (Spec. No. 2266, 2. 9. 65.)

REVELEY'S POWDER consists of:—

Chlorate of potash...	48 parts
Yellow prussiate of potash ...	29 „
Loaf sugar	23 „

It is simply "White Gunpowder" the proportions of which however vary somewhat, those given in Bloxam's Chemistry being respectively two parts, one part, and one part of the above-mentioned ingredients.

AUGENDRE'S and POHL'S are the same mixture, Augendre's answering to that given by Bloxam, Pohl's being identical with Reveley's.

REYNOLD'S POWDER consists of 75 per cent. of chlorate of potash with 25 per cent. of "sulphurea." It is a white powder igniting at a lower temperature than gunpowder and is easily made by the mixture of the two ingredients. "Sulphurea," it is said, can be prepared in large quantities from one of the waste products in gas manufacture. (T. 62.)

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RICKER'S POWDERS consist of ten varieties of chlorate mixture containing a number of substances in addition to the chlorate of potash, such as charcoal, half calcined sea-grass, powdered coal, sawdust, nitrates of soda, lead, or potash, wheat flour, bicarbonate of soda, powdered bark, and dried coffee grounds. The ingredients are all boiled together in water. (Spec. No. 3297, 9. 12. 62.)

ROBERTS' POWDER is WHITE GUNPOWDER made by a wet process and kept in the form of a thin paste, to which a percentage of glycerine is added to prevent it from being dried. The mixture is exploded by detonating an initial charge of the powder (or other high explosive) in a dry state in contact with the pasty mass which forms the main charge. (Spec. No. 926, 14. 3. 73.)

ROGERS proposed a mixture of:—

Chlorate of potash	5 parts
Cascarilla bark	2 ,,
Corundum	3 ,,
India rubber solution	3 ,,

for making blasting fuzes. The object of the corundum or other non-inflammable ingredient is to retard and regulate the burning. The compound was to be dipped in bisulphide of carbon, benzine, or other solvent to mix it. The solvent was evaporated and the mass was ready for making coils or strands. (Spec. No. 1356, 12. 5. 70.)

SANDOY, *see* PYRONOME.

SCHLESINGER'S POWDER consists of:—

Chlorate of potash	3 parts
Sulphide of antimony	3 ,,
Flowers of sulphur	1 ,,

It was proposed for small arms. (Spec. No. 14,227, 20. 7. 52.)

SHARP'S POWDER consists of:—

Saltpetre	2 parts
Chlorate of potash	2 ,,
Yellow prussiate of potash ...	1 ,,
Potash	1 ,,
Sulphur	2 ,,

(Spec. No. 2779, 27. 10. 66.)

SHORT, *see* KELLOW.

SIEMEN'S POWDER is a mixture of saltpetre, chlorate of potash, and a solid hydrocarbon, such as paraffin, pitch, caoutchouc, &c. The compound is mixed by sieves and then treated with a volatile liquid hydrocarbon. A plastic mass is produced which is made into cakes, rendered hard by evaporating the solvent, and granulated. It is stated to be non-explosive when unconfined. (M. No. V., p. 752.)

SLEEPER'S POWDER is a mixture of chlorate of potash, sugar, and charcoal.

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SMITH, *see* SHARP.

SPENCE, *see* RICKER.

TURPIN'S POWDERS consist of mixtures of 80 per cent. of chlorate of potash with 20 per cent. of coal tar and charcoal. In one variety about half the chlorate is replaced by nitrate of potash. Some absorbant of the nature of charcoal, silica, kieselguhr, &c., is added according to the degree of fluidity of the coal tar. The sensitiveness of the compound is increased by substituting 1 to 10 per cent. of permanganate of potash for an equivalent amount of the chlorate. Nitrate of lead may be substituted for saltpetre. (Spec. No. 2139, 27. 4. 83.)

VEIL consists of (approximately) :—

	1	2
Chlorate of potash	50	48·0 parts
Yellow prussiate of potash	4·5	9·1 „
Nitrate of potash	25·0	24·3 „
Willow charcoal	12·5	11·6 „
Paraffin	6·0	6·5 „
Ferric oxide of potash	2·0	0·5 „

(The latter variety is less sensitive than the first).

In external appearance it resembles ordinary gunpowder. It was proposed to be licensed as an authorised explosive, but failed to satisfy the requirements of safety.

WARD, *see* GRAHAM.

WELL'S, *see* HALL.

WHITE GUNPOWDER, *see* AUGENDRE, POHL, and REVELEY.

WIGFALLS POWDER or PRUSSIAN FIRE consists of (subject to variation) :—

Carbon	4 parts	Phosphorus	4 parts
Gums	4 „	Sulphur	2 „
Aqua fortis	6 „	Chlorate of potash	26 „
Red lead	40 „	Sugar of lead	6 „
Cannel coal	1 „	Saltpetre	3 „
Steel filings	4 „		

It is doubtful from its very nature whether the above very heterogeneous and somewhat alarming compound was ever actually made. (Spec. No. 2888, 18. 11. 63.)

WILLIAM'S POWDER consists of :—

Chlorate of potash	48 parts
Prussiate of potash	16 „
Bichromate of potash	2 „
Nut galls	5 „
Cannel coal	2 „
Starch	6 „
Crude coal oil	5 „ —(T. p. 106).

YATES, *see* HARRISON.

ZALIWSKY proposed to mix chlorate of potash with oxalic acid before adding it to sulphur, charcoal or other ingredients. The object was safety in manufacture and manipulation. (D. p. 616.)

(To be continued).

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RECRUITING

FOR THE

ROYAL ARTILLERY.

BY

LIEUTENANT C. D. GUINNESS, R.H.A.

For some time past there has been a constant scarcity of men in the ranks of the Royal Regiment of Artillery. The question of vital interest to us is:—"How, under our present system of Short Service, can this deficiency be made good?

We must not lose sight of the fact that "Short Service" has only within the last few years begun to affect the Artillery. It has diminished the number of "twelve years' service" men who used formerly to re-engage, in order to complete twenty-one years and earn a pension, but who are now turned away with only a suit of clothes and their deferred pay—which, in nine cases out of ten, is all squandered in a week—wherewith to start afresh in life. Thus it follows that we have now no "old soldiers" serving in batteries, in which a short time since they could be counted by the dozen. But, in addition to this, the "short service system" has just commenced to thin out the "seven years' men" by packing them off to the 1st class Army Reserve to complete their twelve years' "Army Service." The wonder is how Majors can find any men who are fit to be dismissed their drills, since, practically, there are no men left who are serving on for pensions; there are very few over eight years' service, except men from India, who are serving on to complete twelve; and Service Batteries have often to supplement the drafts sent out to India from Depôts, by being called on, at short notice, to supply a draft of 10 or 20 men over 20 years of age, and with enough service to put in to make them available for India.

Thus, we can easily account for the great consumption of men which is going on in the Regiment at the present time. But it is quite another affair when we are brought face to face with the question:—"How are batteries to be kept up to the establishment voted by Parliament?" Or, in other words:—"How is the greatly-increased number of men, now required to join the Royal Artillery every year, to be completed, without lowering the standard of either age or physique?" There is a great variety of answers to this problem. Some would have us do away with the "Short-Service system," root and branch; others say that it is best to reduce the establishment, if it cannot be kept up; but I think that it is our duty, now that we have changed the conditions of

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service, to strain every nerve to make these new conditions productive of good to the Army. With this in view, I would like to point out what may be considered to be certain "defects" in our present system of recruiting, which tend to prevent men from joining the Service; and I also beg leave to suggest a few simple "remedies" which, if employed, would, I think, operate favourably on the supply of recruits.

We must bear in mind that since 1880, a perfectly different method has been adopted with reference to the pay of recruiting pensioners and sergeants. Now, a pensioner,[1] while employed in the recruiting service, receives two shillings a day, in addition to his pension, whether he enlists men or not; and recruiting sergeants only get half-a-crown or five shillings for each recruit who actually passes the medical examination and is finally approved of, without anything else to compensate them for the loss they incur in having to provide subsistence for a man who does not come up to the required physical standard. Under these circumstances, is there not a great inducement to an aged sergeant or pensioner, who formerly got twenty-five shillings or a pound a head for every attested recruit, to stay in his quarters and save himself the trouble of tramping about the streets and giving "drinks" to every ragamuffin who presents himself, and tries to do him out of what used to be called the "Queen's Shilling?"—which bounty has also been curtailed. I assert, from personal experience, that these men who had formerly to walk about all day, and perhaps go long journeys by road or rail at their own expense, to get recruits, and are now obliged to be more careful in enlisting men; because it will not pay them to travel to a distant village to pick up some half-dozen boys who have to be fed, and often treated to a liberal supply of drink to seal the compact. Again, these lads have then to be brought to the Army Medical Officer to be passed, or,—as generally happens to more than half their number—to be perhaps rejected, as not being up to the standard of age or chest measurement. It cannot now pay the recruiting sergeant to run any risk, his reward has been curtailed: he has every chance of a pecuniary loss by exerting himself, and nothing to lose by staying at home; for, in the latter case, he gets his recruiting money just the same, so long as he can satisfy the "Recruiting Officer" of the District, who is only obliged to visit the recruiters at out-stations once a quarter, to see that their pamphlets and diaries are correctly kept.[2]

No wonder then that we are short of recruits.

Let us look back for one moment at the old system of giving recruiters one pound per man. What a contrast there is between it and that now adopted! In 1880, I was in a Field Battery at Aldershot, in which there was a Sergeant-Major, whom all the battery looked up to as the father of the battery. While he was stationed there, he saved up some money, and bought a small pony and trap, in which he drove all round the country looking for recruits. The result was marvellous. I should be sorry to say how many men joined the battery

[1] *See* Article 558, Part I., Royal Warrant, Pay and Promotion, 1884.

[2] *See* Section XIX., Paragraph 22, Queen's Regulations, 1885.

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in a given time, but this I know, that in addition to filling up his own, he supplied the other Field Batteries at Aldershot with first-rate men. This Sergeant-Major made a large sum of money in this way, and has now left the Service. The only objection I heard recruits make at that time was that they enlisted, thinking that they would be allowed to serve in a particular battery; but that when they went before the Adjutant, they were liable to be posted to the other batteries where they were wanted. This was a constant source of discontent amongst the men; they complained that they bargained for one battery, and were sent to another; that they joined a Field Battery and were liable to be packed off to a Garrison Brigade. It is not a matter for surprise if they wrote to their friends advising them not to join, and asked their parents to purchase their discharge. Disgust might prompt them to desert, and, after starving for a short time, they might fraudulently enlist in some other corps, and thus rob the country of the value of a free kit.

Again, since the new recruiting system has been in force, Sergeant-Majors of batteries will not allow the messes to supply a meal to men who come up to "have a look what soldiering is like," as has been done; for if these recruits should afterwards fail to pass the doctor, the Sergeant-Major would have to repay the soldiers messes for what was supplied, and he cannot now afford to do this. At present, the recruit is not permitted to enter the barrack-gate until he has been medically examined and passed. The result is, that a poor starving wretch, who, in order to get a meal, says he will enlist, is told to come the following morning to go before the doctor; formerly he would be taken into mess, instead of, as now happens, being forced to go on to the next workhouse to pass the night, and give up the idea of being a soldier.

There is nothing which can help recruiting so much as display, a pretty uniform, medals, spurs, &c. Therefore the more we have of these attractions the better. Make a soldier think something of himself, and he will soon impress an idea of his importance on somebody else. On what other principle does our system of voluntary service depend? I am inclined to think that "Service" batteries at home depend a great deal too much on the depôts for their supply of men. Why should not every battery at home be practically its own depôt, and recruit for itself? Some may say that an order to that effect exists; but how is it carried out? We must remember that it is much easier for Majors of Batteries in the 1st Army Corps to trust to the depôts, especially when a battery at the top of the roster for foreign service is short of men, the authorities post a batch of recruits to it from one of the Field or Garrison depôts. Hence a Major does not trouble about striking N.-C. officers off duty in order to recruit, when he can get men supplied through his depôt. Thus, it often happens, that a battery stationed in Ireland, is recruited altogether from English depôts; so much so that not a single recruit is enlisted locally during the whole of its period of service in that country. This is easily accounted for, as during the recent agitation, Commanding Officers have been very loth to take men who may happen to have

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seditious notions; and it may even happen that in a town, which has completely filled the ranks of one battery, does not furnish one single Irishman to the succeeding battery during its stay there. It really amounts to this :—"No Irish need apply," so long as there are plenty of men being sent from England. Batteries composed entirely of Irishmen have been found to be a mistake, whilst a small sprinkling of Irish recruits in no way affects the discipline of a battery mainly consisting of the English and Scotch elements.

I maintain that in every battery—no matter how strong it may be, and where it may be quartered—the Sergeants should be encouraged to walk about the country, beating up recruits in fairs, markets and villages, obtaining leave, in turn, off afternoon parades and evening stables, until the present dearth of men in the Royal Artillery is remedied. Attractive notices, with coloured pictures of all branches of the Artillery, Horse, Field, Garrison, Mountain and Elephant Batteries, depicted in action and on the move, should also be posted more freely on barrack gates, churches and police stations; men going on furlough ought to be told to point out to their younger brothers "the advantages of the Service."

Depôt Batteries particularly should have several supernumerary N.-C. Officers told off to travel through the large inland towns hunting up men. If we look at the Army List, we find that, with the exception of the London Territorial Division, which has its head-quarters at Woolwich, there is no inland Garrison Artillery Depôt; all the remaining ones are on or near the sea. I believe it is generally admitted that the best men come from the agricultural districts; and I know that at a seaside place, a boy who has got into trouble or is tired of home, in nine cases out of ten, chooses the Navy in preference to the Army for a change of life, and that it is only those belonging to the scum of seaport towns who go into the land forces. But the very reverse takes place in an inland manufacturing or agricultural district; for there, a man looks to the Army as his ideal mode of enjoying himself and of seeing the world. There are indeed Artillery Militia and Volunteer Stations dotted about the country, but these are not sources from which any large number of recruits are derived, and the great majority are on or near the coast. Why not have more Depôt Batteries in the centre of England, in Yorkshire, in the "Black Country," in Ireland, in the Highlands of Scotland? If this were done, the Artillery would have a better chance of competing successfully with the Line for the supply of the raw material. Of course, it is easy to see that the Colonel of a Regimental District in Scotland, would be anything but pleased to find the Artillery enlisting sturdy fellows in his favourite recruiting grounds in the Highlands. But, on the other hand, why should it be assumed that a Scotchman would make a bad gunner if he did not wear a kilt?

At present, a man wishing to join the Royal Artillery has to go either to a Post Office or to a pensioner, who is paid for recruiting for the Army at large, and who, in nineteen cases out of twenty, is really working for a Line Regiment. An old Infantry soldier naturally tells a smart lad that his own branch of the service is the best; and so he

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is packed off to the nearest Infantry Brigade Depôt, where he probably changes his mind, and ultimately joins the Line to the detriment of the Royal Artillery.

If we take the District Commands at home, and start with the first one —the Northern—we see that it contains two Field Artillery Depôts, and that these are at Newcastle-on-Tyne and Preston, and two Garrison at Sunderland and Liverpool, all on the sea coast; whereas, the head-quarters of the command are at York, the capital of the largest county in England. If we examine more closely, we find that there are only five Field, but no Horse or Garrison Service Batteries in this District, which comprises nearly the half of England, and contains, amongst others, the following counties:—Anglesea, Cheshire, Cumberland, Derbyshire, Herefordshire, The Isle of Man, Lancashire, Northumberland, Staffordshire, and Yorkshire; whereas the Infantry Depôts in the same District number twenty-six.

I doubt very much whether Artillery Depôts are useful at present, except as centres for clothing and teaching men the first elements of drill. A N.-C. Officer told me that all the men, with very few exceptions, who joined a particular Depôt in which he served, came from a distance, and were sent either through the Post Office, or by the paid recruiters scattered about the country; and that in a period of three years, he could scarcely count a dozen men who, in his recollection, had presented themselves at the barrack gate.

Again, when a Militia Brigade of Artillery or Battalion of Infantry is about to be disembodied at the conclusion of its annual training, it would be a capital opportunity for sending some of the Sergeants from Depôt Batteries to persuade the Militiamen to enter the Royal Artillery instead of returning to civil life. This is occasionally done, but the number of men thus obtained is unfortunately very limited. Militiamen are to be preferred to the ordinary class of recruit; because they have tried their hand at soldiering and have taken a liking to it; and also because the work of the drill sergeant will be considerably reduced by their previous acquaintance with the ways of the service. Out of one batch of thirty recruits sent to a Service Battery, there were nine who had served either one or two trainings with the Militia, and who, instead of going back to their homes, had enlisted in the Royal Artillery. There were also four Volunteers in this draft, and these knew their drill better and were more intelligent than the Militiamen or the other recruits.

It is said the Volunteers will not enlist in the regular forces, because they are a superior class and will not face the coarseness of the barrack room; but here is proof to the contrary; and there is no doubt that they are the very stamp of men we most want, they make good N.-C. Officers, especially as owing to "Short Service" we are very often obliged to put the stripe on boys under a year's service. The attractive notice boards mentioned above, should be hung up conspicuously in every orderly room and drill hall belonging to the Militia and Volunteers.

There is no doubt that the new Infantry Territorial system has, to a considerable extent, drawn away recruits from the Royal Artillery;

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for instance, the Hampshire Regimental District is in a highly satisfactory state as regards recruiting, and keeps its two Battalions well supplied with men; but although it furnishes men to the Royal Artillery, yet I think that an agricultural labourer would prefer to go into the Regiment which bears the name of his county, and which contains men born and bred in his own native village, than to enter the Artillery, and be sent off to serve with a Battery in which he has no acquaintances, and whose name and designations convey no home associations to his mind.

All the papers and magazines, especially the *Nineteenth Century*, used to be full of letters and articles deploring the condition of the Line; but not a voice was raised to place before the public the numerical weakness of nearly all our Batteries on the home establishment. Now the Line is so full that over 1500 men are about to be transferred to the Artillery, partly to make up the six new Garrison Batteries, and partly to fill up the old ones. It is questionable whether these men will be the pick or the pickings of the Line Battalions. It seems as if the Royal Artillery were nobody's child and not worth troubling about, whereas if its present condition, with respect to numbers were generally known, it would startle the British public. I believe that this great deficiency could be partly made good as follows:—

First, by recruiting when on the march. Let every Horse and Field Battery when ordered to change its station, have some three or four experienced N.-C. Officers attached to it from a Depôt or from another Service Battery for recruiting purposes only. These would come under the heading of "Special Recruiters."[1] Let them march in advance of the Battery and distribute notices at all the villages along the road, with the billeting party, to give notice that troops are to come through on the following day, and that all young men will be welcomed who wish to enlist, provided that they can pass the doctor.

By the time the Battery marches in the next day, all the young men in the place will be assembled, if only out of idle curiosity, to see the soldiers arrive, and a few friendly words from the men while in billets, would do wonders towards getting recruits. When on the march through the midland counties, I have been struck with astonishment at the large numbers of men who came up, wishing to join the Battery. We were in the 1st Army Corps, and unable to take them, as we were up to strength. Many said that they never had seen any Artillery before; this was in places through which no Artillery had passed for some years.

Would it not be worth while to make a Battery occasionally turn a 10 days march into one of 15 days, by going along a circuitous route, for the express purpose of filling its ranks? We must remember that, when in barracks, the men scarcely ever go more than two or three miles away into the country; and that in consequence, civilians, except those living in garrison towns, know little or nothing about the life of a soldier; so what must be the effect of a glittering show of uniforms, guns and horses, on the minds of the inhabitants of a small place in which a soldier is not seen from one years end to another?

[1] *See* Paragraph 6, Section XIX., Queen's Regulations, 1885.

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By striking while the iron is hot, before these favourable impressions have had time to wear away, a great many recruits of a superior stamp could be procured.

Now, supposing several men wished to join a Battery on the march, there would be really no difficulty about getting through the formalities of enlistment; for every Battery marches with a Medical Officer in charge, who could examine the men wishing to enlist; so that next morning one or more of the recruiting sergeants could bring the recruits before a Magistrate for attestation; after which they could be put into the train, and taken, on a warrant from the Officer Commanding the Battery to the nearest Depôt or town where Artillery is stationed. As soon as the recruits have been handed over at the barracks, the Sergeants could rejoin the Battery.

The reason why Majors of Batteries do not recruit when on the march is that it gives some trouble to their Qr.-Mr.-Sergeants and Nos. 1; as these would have to look after a set of useless men in addition to their other duties; these recruits would have to be fed, paid and billeted; and all this complicates the pay books and other accounts of the Battery. If any recruits should join during a day's march, they could be brought on with the Battery to the town where it is to halt that night, and they could be sent off with the next batch of men.

Secondly, many more men could be got to join the Artillery by telling off two or three "special" Recruiting Officers, either Captains or Subalterns, to go about the country to fairs, markets, and to places where men are out on strike, either in manufacturing or colliery districts. Each Officer might have half-a-dozen "recruiters" under him. The mode of procedure would be for the six recruiters to start off in different directions; and to post illustrated notices and advertisements, describing the advantages of joining the Royal Artillery, on all the police barracks, court houses, public places and post offices in the villages and towns in a certain district. These bills should state that an Officer will attend at a fixed time on a certain day to take the names of any eligible young men who wish to join; and that he will explain any particulars about the Service which may be desired. By this means, the Recruiting Officer would be able to visit a different locality every day in the week, and see that the work was properly done. Recruiting Sergeants would have plenty of time to get men together for his inspection. Encouragement should be given to the Sergeants by means of advancement and extra pay, according to the number of men who are finally approved and passed into the service through their agency.

The Foot Guards have the privilege of enlisting men out of their own districts, through the agency of "Special Recruiters;" although the Queen's Regulations lay down distinctly[1] that all men offering to enlist in Regimental Districts are first to have the option of joining the Royal Artillery or Royal Engineers, and then the Foot Guards—

[1] *See* Paragraphs 36 and 37, Section XIX., Queen's Regulations, 1885.

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provided that they are eligible for either of these Corps. It is doubtful whether every recruit entering the Line has the meaning of this question clearly explained to him. If the Guards have the right of choosing their own locality for recruiting, surely the Royal Artillery might also be allowed to do the same, and appoint "Special Recruiters," as long as it continues to be short of its establishment.

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FIELD ARTILLERY FIRE, ORGANIZATION AND DISCIPLINE.

BY

CAPTAIN E. N. HENRIQUES, R.A.

"FIRST it must *hit*, second *hit*, third *hit*." Thus, Kraft, Prince of Hohenlohe-Ingelfingen tersely expresses the first requirement of good Artillery.

The strange contrast which is so often found between theory and practice is very marked in our Artillery. All readily assent to the maxim that hitting should be the artilleryman's guiding principle, and that all his other aims should be made subservient to it. Hitting is in fact the life and *raison-d'être* of Artillery, yet this prime object does not unfortunately always receive full practical recognition, either by the regulations of the service, or by many officers, who take the greatest pride and interest in the perfection of our Arm.

The few remarks I have to make will I trust, add in some measure to the utility and power of our glorious Arm, by suggesting the outline of a system for bringing to the front and training a body of efficient marksmen, and employing them in the most advantageous manner.

In our service (as in all others I believe) it is the duty of the Nos. 1 of sub-divisions to lay their guns. This No. 1 is, with us, chosen on account of his aptitude for command, his trustworthiness, general intelligence, and superior education. His duties at gun drill are laid down by authority in the "Handbook for the 12-pr. B.L. gun, (Mark I.) 1887," as follows:—

"No. 1 ships and unships the handspike, stands at the end of it, commands, lays, adjusts metal time fuze when required, removes safety pin, enters the shell its own length in the bore, lifts at the end of handspike in running up or back." There are besides many other details given regarding general supervision.

On active service in the field the duties and responsibilities of the Nos. 1 are much increased. In the midst of the excitement and confusion of action, he must observe the effect of his fire, maintain fire discipline, closely watch the movements of the enemy, carry out the objects of the C.O., while preserving imperturbable steadiness and calmness in laying his gun, correcting ranges, setting fuzes, etc.

The natural qualities which appear to me required to make a good marksman are—(1) Good and quick eyesight; (2) The power of obser-

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vation; (3) Calmness under all conditions; (4) Fair general intelligence, and it is only by careful training and practice that these qualities can be brought to any degree of perfection. I need scarcely insist with gunners on these self-evident qualifications. I shall, later on, however, have some remarks to make on No. 2, "The power of observation."

Now I cannot see how the requirements for making a good marksman can possibly be ensured to the No. 1 chosen as he now is. It would indeed be a mere chance if he were so endowed. I have known of a battery in which the tailor gained the highest score at annual practice. Quickness of eye and capacity for delicate adjustments and observations are qualities to be found in all ranks, as is clearly shown by our range-finder experience.

Allowing for the sake of argument that the No. 1, besides being fully qualified for the command and discipline of a sub-division, can lay his gun perfectly, I still consider (taking all the conditions of active service into account) that he has too many details to look after, to allow of his laying his gun with calmness and precision. To lay on any object, unless quite stationary and definite, requires the greatest care and attention in studying the object and making adjustments. Can this undivided attention be given, I would ask, by a man who has eight gunners to look after, to see to the correct preparation of projectiles, and the general working of the gun and fittings?

In these days when Artillery has often to open fire at over 5000 yards range, I believe that Scott's telescopic sight will invariably be used, and although in general principle and working (requiring only mechanical adjustments) it is easier to use than the ordinary tangent sight, there are fine adjustments and observations to be made in order to get the maximum accuracy, which call for greater coolness and precision—in fact the laying number's entire attention.

If these considerations have any weight, certain changes in our drill and training will follow. I would suggest that these changes take the following form:—

The laying of the gun should not form part of the duties of the No. 1.

There should be four numbers at the gun instead of three, and the extra number should be a specially selected marksman to lay the gun.

Should it not be considered expedient to take one of the "reserve" Nos. (6, 7, 8, and 9) for this purpose, the same object can be *partially* attained by making No. 3 lay the gun, and No 1 traverse. At the word "Action" Scott's sight would be brought up by one of the "reserve." After having put the right break in gear, No 3 would take the sight, adjust the focus and elevation, and place it in the V's, and prepare to ram home the projectile. While the breech is being closed he will ship the handspike and then proceed to lay the gun.

We now come to the selection and training of marksmen. I wish first to observe that, although the raising of the general average of the shooting of gunners is in itself a good and wholesome aim, it can be carried a step too far. We do not stand, in this respect, in the same position as Infantry and Cavalry, where each individual has the same opportunities for destruction. Only one man in a sub-division

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can lay the gun and it should therefore be our object, while making all generally efficient, to pick the men best qualified for marksmen, irrespective of rank, and having made the best selection, our chief energies should be concentrated in training them to the highest pitch of perfection.

Another very important consideration points to the same course. It is the universal complaint that our ammunition for practice is very inadequate, and however much it may in future be increased, I feel sure this complaint will always be heard. It behoves us the more, therefore, to set about using our practice ammunition to the best advantage, to attain the highest efficiency of our batteries. And I contend that the attainment of a high general average at battery practice does not effectually promote this object. It is the best marksmen only who should practice under service conditions at our camps. A few rounds of plugged shell are quite sufficient for the remainder of the gunners.

The training of recruits should be begun by instructors, who will ground them thoroughly in all the details of standing gun drill and stores. The details and practice of laying should be deferred to a later stage.

Gunnery Instructors should be fitted for this work, and strictly limited in their instruction of recruits to elementary grounding. It is I believe the experience of others, as well as mine, that Gunnery Instructors are too prone to gabble off their drill books by the yard. They repeat long processes of manufacture and construction which they do not themselves perhaps thoroughly understand. The main result of this is to impress the recruit with a sense of mystery and of the deep learning of his instructor. On the whole it tends to confuse him and take his mind off practical essentials. The patience, tact, and system by which drill is ingrained upon a recruit, however dull, and made a second nature to him, are not readily found in these days.

For instruction in the theory of gunnery and the manipulation of delicate instruments, I am persuaded that an officer, however slight his practical experience may at first be, is far more capable than the average drill instructor. Yet another reason why officers should give special care and attention to this branch of instruction is that the officer, who makes the choice of marksmen, must study the character and idiosyncracies of his gunners closely, otherwise his selections will not be sound.

I have spoken of the "Power of observation" as one of the natural qualifications needed for laying. It is a point which has hitherto received but scanty attention. Most minute and precise observations are absolutely essential in laying and correcting ranges under the conditions of modern warfare. The immense difficulty of fixing a particular spot at long ranges over varied ground is patent. To correct ranges the laying number must be able to do this accurately, and keep such a spot in his mind for some considerable time, while at the same time he has perhaps to watch a moving enemy. This aptitude must be assiduously sought and cultivated in those gunners who possess it.

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Under such a system as this a certain number of recruits will be selected, who are considered qualified to profit by a more extended and thorough training in laying. Eventually the six best marksmen will be appointed marksmen to the battery. These appointments should be made as attractive as possible, and emulation at competition excited. They should receive extra pay to bring them nearly on a level with the Nos. 1. They should be constantly kept in practice and under trial. Drunkenness and all irregularities tending to their deterioration (in point of steadiness and nerve) should be visited with a special scale of fines, higher than the ordinary. Men physically unfitted for active service should not hold these appointments. Competition for these posts should take place at every service practice. But a marksman once made should not be superseded unless he falls more than once below a fixed standard of efficiency, even though he should not come amongst the six at the top of the competitors. On the other hand, if there are other reasons in conjunction to disqualify him, no single effort to gain a high position at competition should be considered sufficient reason for retaining a doubtful man. In this manner uncertain men will be excluded, and the element of chance eliminated as much as possible.

The maintenance of fire discipline has for many years been held of the highest importance by the Germans, and noticing foreign criticism on this subject, I am supported in my sense of our deficiency in this respect. We are in much need of precise regulations on the subject, so that each shot fired may be properly supervised, and the rate of fire may be regulated by the battery O.C., according to the requirements of the occasion.

In these days a larger expenditure of ammunition is required of Artillery, and at the same time greater mobility is demanded. Artillery now comes into action, first at very long ranges before the other Arms are engaged, to enable the General commanding to form his plans and develop his attack. Then it advances to decisive ranges, to crush the hostile Artillery, to prepare the way for the other Arms, to support their action, and to follow up their successes at every stage, until the enemy is out of reach. Unless every shot is made to tell, and due caution and management are exercised in the expenditure of ammunition, batteries will find themselves very quickly without any means of attack or defence.

LONDON,
August, 1887.

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OBITUARY NOTICE.

GENERAL W. J. SMYTHE, LATE R.A., F.R.S.

BY

GENERAL SIR J. H. LEFROY, C.B., K.C.M.G., F.R.S., LL.D., R.A.

General William James Smythe, R.A., born 25th January, 1816, who died on the 12th July, 1887, was in early life very much connected with the R.A. Institution, of which he became Secretary in July, 1839, and filled that office rather more than two years, having previously served at the Cape, where he took part in the Kaffir War of 1835–6. He was next in charge of the Observatory at Longwood, St. Helena, for five years (1842–6); they were laborious and busy years for him, whose fruit will be found in two large quarto volumes of observations brought out by General Sabine, in 1850 and 1860. The peculiar quaint dry humour, which was so characteristic of him, found expression now and then even in the grave discharge of his scientific duties. "I saw in the papers" he writes to Professor Lloyd "that the Pope had anathematised the performers of animal magnetism, I trust this included insects that have the vanity to recreate themselves with a see-saw on the vertical force needle." He alluded to a source of disturbance that has given trouble to almost every magnetical observer. A spider, for instance, casting a fine, almost invisible line, to a suspended magnet, and causing unaccountable jerks, or a microscopic beetle disturbing the delicate balance of a horizontal beam.

Captain Smythe left St. Helena early in January, 1847. It is to be regretted that he had an adversion to having his letters kept, and often made their destruction a sort of condition of correspondence, for at this time they were often witty, in an uncommon degree.

In August, 1848, he embarked for Halifax, but returned in August, 1849, and in January following was appointed by Lord Anglesea to the newly created office of Director of Artillery Studies which he held to July, 1852. Having a good knowledge of German, he was selected in October, 1854, to superintend the execution of contracts for arms in Belgium and Germany, and while still holding that appointment was appointed by Lord Panmure, Member of a Commission, issued by him in January, 1856, to consider the best mode of re-organizing the system for training officers for the scientific corps—his associates were

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Lieut.-Colonel W. Yolland, R.E., and the Rev. W. C. Lake, a distinguished educationalist and Inspector of Schools, now Dean of Durham. It was unfortunate that the two military members of this Commission did not work harmoniously together, their views, and perhaps their aims, were at variance. Lieut.-Colonel Smythe was, and remained to the end of his days, a strenuous advocate for separating the education of the Royal Artillery entirely from that of the Royal Engineers; Lieut.-Colonel Yolland, keenly alive to the advantage of his own corps of its almost invariable selection by the first-class men of every batch, and of getting the *élite* of a large body of candidates instead of a small one, was in hopeless antagonism to him. In the end the report was drawn up by the Rev. W. C. Lake and the Secretary. Lieut.-Colonel Smyth refused to sign it, and finally did so, "For the History and description of Foreign military schools only."

The Report, presented to Parliament in 1857, offers a wealth of information, and preserves the well weighed opinions of a large number of the most thoughtful Officers of both corps; it is now in some measure obsolete, but is still well worth study when any question of higher military education is mooted.

Colonel Smythe was again appointed Director of Artillery Studies in 1858; in his two terms of office he conducted several small parties of young officers on military tours, for which a provision of £400 per annum was made in 1853. He was appointed a Member of the Ordnance Select Committee in 1859, and the same year brought him an appointment of a different and very interesting nature. That sometime truculent savage and cannibal, King Ebenezer Thakombau, whose conversion to christianity (whether dictated by policy or conviction) is one of the most surprising triumphs of missionary enterprise in the Pacific, made up his mind in 1858 to cede his dominions to the Queen of England; and the British Consul, Mr. W. T. Pritchard, deemed the offer of such importance that, without waiting for leave, he personally brought home to England a formal deed of cession, bearing date, 12th October, 1858, and signed "*Tui Viti* (*his* × *mark*)." Mr. Pritchard did more than this, for he procured the enactment of a law by the Chiefs, conferring "full, unreserved, entire, and supreme authority and power on himself to govern Fiji, according to the broad and plain principles of justice and morality," and to make what laws he pleased! These over-zealous proceedings led to his recall.

In the meantime the Duke of Newcastle, Secretary of State for the Colonies, looked about him for a Commissioner, in whose judgment, firmness, and integrity, he could place full reliance, to proceed to the Fiji Islands, and enquire, on the spot, into the competency of King Thakombau to make the cession, the existence or not of a general desire among the natives to come under British Sovereignty, and on the value of the group from a strategetical as well as a commercial point of view. His choice fell on Colonel Smythe, who accordingly left England in January, 1860, for Sydney. On his arrival there, he found that the war just broken out in New Zealand put it out of the power of the Commodore on the station to forward him to Fiji in a man-of-war, and after some delay he was obliged to charter a small

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vessel, the *Pegasus*, of 50 tons, to get to Levuka, which he did on the 5th July. Many instances might be quoted of the advantage to the service of Officers being familiar with the sextant, and having some acquaintance with nautical astronomy.[1] His voyage from New Zealand furnishes one of them. Mrs. Smythe in her charming narrative [2] thus relates it—"For the next few days (after leaving Auckland) the "weather was very unsettled, every opportunity was taken of getting "observations, and as W. and the Captain have each a sextant and "chronometer, there is a constant comparison of results. W.'s "experiences in these matters proved of considerable importance to "us. When near the 180th meridian, it is very possible it appears to "make an error in the longitude, as to whether it is to be reckoned "*east* or *west*. The Captain committed this error, and would not be "convinced he was wrong until we sighted one of the Kermadec "Islands, which settled the point. The mistake amounted to about "100 miles—rather a serious matter in the neighbourhood of islands. "In justice to the Captain, however, W. says that the ordinary text-"books on navigation are not sufficiently explicit in their directions "in this particular case."

Colonel Smythe took the most practical method of ascertaining native opinion, by visiting in turn all the larger islands, and holding public assemblies under the local chiefs, he found little or no organised opposition to the cession, but found also that Thakombau was in no sense King of Fiji, that it was not in his power to make good his promise to convey 200,000 acres of land to Her Majesty as an equivalent for the payment of certain American claims, and that the representations made to H. M. Government as to the value of the islands, were in many substantial particulars incorrect. He reported accordingly that he was of opinion "that it would not be expedient that Her "Majesty's Government should accept the offer which has been made "to cede to Her Majesty the Sovereignty over the Fiji Islands," and he had the satisfaction of seeing his report approved.

It is needless here to enter into the subject of the subsequent cession of the islands in 1874.

Foreseeing a tolerably long detention in Fiji, Colonel Smythe took down with him the materials for putting up a small house, which was erected on Levuka, part of it being fitted up as an observatory. Here he made magnetical and meteorological observations from 1st January

[1] Perhaps the most remarkable of these was presented in 1851, when Second-Captain G. H. Vesey, R.A., now Major-General, was proceeding with a detachment to St. Helena, in a small merchant vessel of 300 tons, and, in consequence of the drunkenness and aggressive acts of her Captain, felt himself under the necessity of taking possession of the ship. He gave charge of her to the first mate, but not having confidence in his competency, and having taught himself navigation in the long voyage, he daily examined the course as laid down on the chart, and worked out the observations. The day before he expected to arrive he found an error of one degree in the latitude, and that she was steering for a point 40 miles to leeward of the island, if she had held on that course, they must have run for Rio, as their water was nearly run out. As it was they corrected the course, and made the island exactly. Captain Vesey was tried in the Civil Court for his vigorous but illegal act, and sentenced to pay a fine, but the Government indemnified him.

[2] Ten months in the Fiji Islands, by Mrs. Smythe. 8-vo. J. and J. Parker, 1864, p. 12.

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to 30th April, 1860, including very careful determination of magnetic declination, inclination and force. Although not the first good observations made on the group, they are the most extensive and complete, and will probably long remain the standard of comparison. Returning to England by way of Panama, he reached London in November, after which his military service came to an end with two short tours of duty in India. He was elected a Fellow of the Royal Society in 1864, and was for some years a Member of the Meteorological Committee. He was a Member of the Royal Irish Academy, and of other Societies.

His latter years were chiefly given to an earnest advocacy of Home Rule for Ireland, not indeed in the sense of the Nationalist Party, but so far as compatible with continued union with Great Britain; and as a means to this end, he devoted himself to the encouragement of the Irish language, which he considered to be one of the oldest and most interesting of European languages. He made some considerable progress late in life in acquiring it. By his will dated November, 1886, he directs his Trustees to pay to the Royal Irish Academy, in reversion, the sum of £3000, in trust, "to invest the same in whatever manner the Council of the said Academy might deem prudent, and to apply the interest thereof towards the encouragement and promotion of the Irish language by the publication of books, giving aid to teachers of the language, or by such other ways as might appear to the said Council most desirable." He leaves the reversion of an equal sum, together with his residuary estate, if any, to the Representative Body of the Church of Ireland.

The strong union in him of devoted attachment to his Church, with antiquarian leanings was evidenced several years before his death, by the erection in the churchyard of Carnmony, over his intended burial place, of a lofty Irish cross in mountain limestone, designed from the finest examples extant, and probably the most beautiful and costly modern specimen of Irish ecclesiastical art in the country. It bears in Latin and in Irish the texts Rom. viii.–32, and Gal. vi.–14, each in its appropriate character, with other inscriptions. The loss of a layman so forward in good works and acts of munificence, of a patriot so pure and honest, called forth many public expressions of respect and regret. His "original, ardent and noble spirit" has been recognised by one of the most learned of Irish Bishops, who herein but expressed the sincere regard he had unconsciously the power of awakening in those admitted to his intimacy. He lies at the foot of the Cross he erected, with the simple record.:—

AT THE FOOT OF THIS CROSS
REPOSE THE MORTAL REMAINS OF
GENERAL WILLIAM JAMES SMYTHE, F.R.S., M.R.I.A.,
(ROYAL ARTILLERY.)
WHO DEPARTED THIS LIFE, JULY 12, 1887.

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TIME, PACE AND SPEED.

BY

LIEUT.-COLONEL T. B. TYLER, R.A.

THERE appeared in the September number of the "Proceedings," the translation of an article from the *Journal des Sciences Militaires* under the heading "Artillery before the Battle," contributed by Captain W. P. Thring, R.A. In the concluding paragraph of the translation the following passage occurs:—"From the first day the driver has a pair "of horses to drive till the end of the manœuvres the Instructor must "not lose sight of the object to be attained, viz., to arrive rapidly on "the field of battle." This passage furnishes the key-note to the whole paper, and the subject is one, which, though much discussed, is little practised in our service.

In recent wars there have been no occasions when our Artillery have had to move rapidly over long distances before an action; and in peace time, though there is a good deal of marching, no test is applied which would enable an officer to state definitely the shortest time, for instance, in which his battery could cover 20 miles over roads described to him. This, I think, he ought to be able to do. I am aware that trials of this nature have been carried out with success in India, but the conditions of marching there are so different from those at home, that few deductions can be drawn from those trials which would be of much benefit in determining similar ones here. Besides, the results of those trials are not generally known, and they were probably made with 9-pr. guns, so the experience gained by them would not be reckoned as conclusive by officers commanding batteries of 12-prs., 13-prs., or 16-prs.

Though our batteries march a great deal at home, not much is learnt in the direction of rapidity of movement; for the most part a battery marches with a view to saving the horses as much as possible, and in the case of a Field Battery its pace is obviously limited by the fact that all the men cannot be carried.

In the paper I have quoted it is stated;—"in order that the whole of "the Artillery of an Army Corps may arrive on the field of battle in "good time and in good condition it is necessary that it should be "able, without exhaustion, to cover 9¼ miles at a trot, in an hour and "a quarter." This is very good going indeed. On the last march I made with my Battery, B/A, R.H.A., we completed 27 miles in 5 hours, and in one of the hours we covered 7 miles, but the road was level and very good, and the horses were in Aldershot condition. Colonel C. E. Scott told me that he had marched with his 9-pr. Field Battery

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18 miles in three hours and a quarter—a very good performance. To quote again from the same paper: "the field batteries from Saarbruck "marched 34 kilometres (about 20 miles) in 4½ hours; but on that day "they had previously marched 22½ kilometres (about 14½ miles)." It is not stated on what kind of roads these movements were made. Again: "batteries should be in a position to make forced marches of 37 miles."

Now I am far from wishing to imply that our batteries could not perform these feats—indeed it is quite certain they would excel them; we have better horses (the average height of the French Artillery horse is 14 hands 3¾ inches) and we believe we know how to get the most out of them; but what I desire to point out is that our officers and men do not know what can be accomplished when the supreme moment arrives, and I cannot but think it would be of great advantage to the Service if such trials were made part of the annual course, and that batteries should be called upon to perform a march as a part of their inspection. The trial need not be a high one; Horse Artillery might, for example, be required to cover 12 miles of selected roads in 2 hours, and light Field Batteries 10 miles in the same time, the finish to take place in the presence of the inspecting officer. It would probably be found that with the practice which officers would undoubtedly give their batteries, these distances would be covered with ease within the specified period; but however that may be, a far better idea could be formed of the condition of the horses, and the fitness of the battery for service than can be arrived at under the present system of parades.

"I would especially recommend that long distances be covered at a "trot in column of route and in line. (Horse Artillery should practice "long gallops in line), and that such movements should form the "principal part of the drill. It is of the greatest importance that "during these lengthened and rapid movements the steadiness of the "pace and perfect quiet should be preserved, so that the horses may "not be annoyed by constant checks, nor be tired out by being "suddenly started. This is very difficult to manage, since, especially "at curves and corners of the road, intervals are apparently soon lost, "and then the guns bound on, and any rebuke of the officer is "unheard on account of the deafening noise of the carriages. In war, "as I have said, many miles must often be passed over at a trot, in "column of route. Wherefore we must in time of peace practice "trotting at least 4½ miles without exhausting the horses. We also "ought to practice forced marches of at least 30 miles in the day, so "that all may learn how this is to be done without injuring the horses. "We shall then be able in war to get over 60 miles, when we are "ordered to do so at whatever cost. That Artillery should be able to "do this as an ordinary thing is more important than the execution of "the most elegant drill movements." So writes Prince Kraft who, though he has contributed to the History of Field Artillery the most valuable chapters ever written on it, has not, it must be admitted, much faith in drill books.

A good coachman can tell you, at any part of a stage, at what pace he is going, what he is taking out of his horses, and what time he will

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arrive; the judgment of time, pace and speed is to him an instinct derived from practice and watchfulness; and it is these qualities which must be developed and attained by an officer who wishes to get the most out of his horses with the least amount of distress to them. And, as few men possess so intimate a knowledge of the powers of their horses as to be able to measure the capacities of all the teams of a battery, the subaltern officers should be encouraged and empowered to make such independent marches with their divisions as will enable them to acquaint themselves with the proportions of time, pace and speed, which give the best results when put to the test.

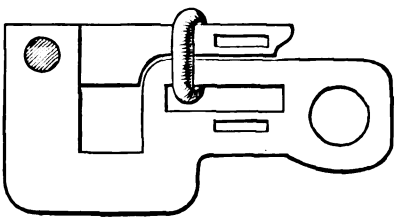
I am well aware that a system of trials such as I suggest will meet with scant favour among battery commanders, who are for the most part possessed with a deep-rooted dislike to putting their horses to any sort of trial whatever. Their horses are too old or too young, too fat or too thin, or something has occurred or is about to occur, which will render the project impracticable; indeed I am by no means certain that I myself, when in charge of horses, should have received the suggestion with enthusiasm; but, I should have said then, as I say now, that if an officer be asked how long it will take his battery to cover 20 miles over certain described roads, he ought to be able at once to give the time within 20 minutes. It is doubtful whether nine officers out of ten would get within three times that period; and if this be so, it is not necessary to point out in what way this want of knowledge might affect the operations of a General who has enquired from his Corps Artillery how long it will take them to arrive at certain points, and has based his plans on their reply.

IMPROVED TRACE HOOK.

BY

COLONEL J. HAUGHTON, R.A.

REFERRING to the ingenious pattern of trace hook brought forward by Major Gambier, R.H.A., in this Journal for July, it may be useful to describe a pattern used by me in E/16, R.A., in 1869. The pivot is at the outer side and so there is so strain on the tie. The following sketch of my hook will explain itself.



LUCKNOW,
22nd Sept. 1887.

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THE NEW SOUTH WALES ARTILLERY.

BY

MAJOR E. BINGHAM, R.A.,

(Local Lt.-Col., Brevet-Col., and Chief Instructor, N.S.W. Artillery).

Some of my brother officers may care to learn what work is being done by gunners at the Antipodes.

The armament of the Colony consists of guns of the following calibres :—10-inch (25-ton) M.L.R. (Armstrong's) ; 10-inch (18-ton) M.L.R.; 9-inch (12-ton) M.L.R.; 80-pr. converted M.L.R.; 40-pr. B.L.R.; 16-pr. M.L.R.; 9-pr. M.L.R.; also a few 10-inch S.B., 68-pr. S.B., and 32-pr. S.B. on travelling siege carriages. There are altogether 53 guns mounted on the coast line of the Colony, some in strong modern forts, and to these will shortly be added, 30 guns of 8-inch and 6-inch B.L. on H.P. carriages; also 40 Nordenfeldts of 1½-inch, 1-inch, and ·45-inch have arrived but are not yet in position.

We have established a small "Shoeburyness" at the Middle Head of the beautiful harbour of Sidney, and have already had three courses of 50 N.C.O.'s and gunners each, together with some of the junior officers of the Permanent Artillery. The courses are instructed in the drill and practice of all the different natures of guns in the Colony, in addition to theoretical knowledge of gunnery, ammunition, knotting, splicing, &c., and also in the drills of light and heavy gyns and Repository Exercises; all the officers and N.C.O.'s and a good proportion of the gunners pass most creditable examinations at the conclusion of the courses, and are granted certificates of merit in their several ranks.

I regret to say, that owing to financial difficulties of the Government, the Permanent Artillery have been lately reduced from 500 to 375, and the Volunteer Artillery, of which there are 11 batteries, have been cut down from 80 to 60 men per battery. This is greatly to be deplored, as not only have they lost a number of good men who had passed through the courses, but the numbers left are not sufficient to man the existing guns, and when the new armament is mounted they will be dreadfully short handed.

The junior officers, N.C.O.'s and men, that have passed through our hands are most intelligent, and very anxious and willing to learn everything about their profession. Included in the above numbers there are two so-called Field Batteries of four guns each, one of 9-pr. M.L.R. guns manned by the Permanent Artillery, and the others of 16-pr. M.L.R. guns manned by the Volunteer Artillery, and both

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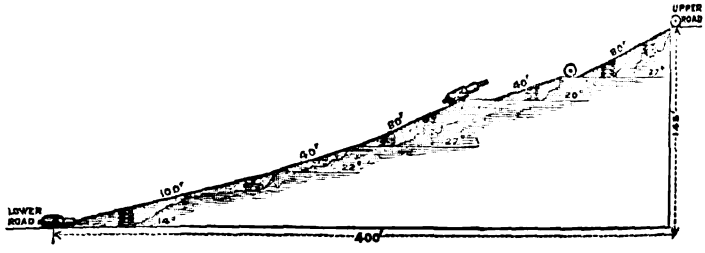
horsed some 10 or 12 times in the year with hired cart horses; also a battery of four 40-pr. B.L.R. guns, to be horsed in case of necessity, and manned by the Volunteer Artillery. These may be briefly described as useless and expensive during peace and dangerous in war, and will remain so until the Government see their way to buying a certain number of horses, so as to teach the men to ride and drive and accustom them to their horses and the horses to their work. There is no establishment with these batteries except the actual gunners and untrained drivers, and no provision at all is made for the wagons.

The permanent gunners are a great deal interfered with in their proper work by having to furnish daily guards of 15 men and four N.C.O.'s, thus taking 33 men and four N.C.O.'s daily from drill; and with the number of men on detachment, and those required as assistant master gunners, caretakers, storemen, and men regimentally employed, it is difficult with the exception of the 30 men I have at present going through a course, to get any man for actual gun drills. I am ably assisted in the work of instruction by Capt. W. St. P. Bunbury (local Major) Master Gunner Tristram, R.A. (late of the Experimental Branch, Shoeburyness), Lieut. C. Milward, R.A., (local Captain) is at present acting Adjutant to the Volunteers, (their own Adjutant going through the course), and by Sergt. Breans, late R.A., formerly a Sergt.-Instructor at Shoeburyness. Great difficulty is experienced in getting proper stores, and even now, nearly two years after requisition, I have not been able to get some necessary cordage, and have to do the work with anything that comes to hand; Colonial rope is not to be trusted to take the same strains as our English rope; there is not a sling to be trusted in the Colony. Levers, hankspikes, and skids, made of the wood of the country, although nearly as strong as iron, are heavy and unwieldy, and most cumbersome and slow for our work.

I will now give you a sample of the work done by the squad at present under instruction, which I think would be creditable to any similar squad of Royal Gunners. A 10-inch 18-ton gun had to be taken down from an emplacement on the top of a cliff and mounted in a new iron casemate fort at the bottom. The road for half the distance was a good metalled one, and we parbuckled the gun along in good style. At the bottom of this good road the gun would have to be brought back along a cart road for about three-quarters



of a mile at about the same level as the casemate. When about half way down the good road, and at the top of the steep incline, it struck me, that it would be better to lower the gun over the cliff down to the

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lower road, and thus cut off more than half a mile. The total distance to be lowered was about 400 feet and the height 145 feet, but it was divided by ledges of rock into steep slopes from 27° to 20° varying from 80 feet to 40 feet in length. The ground was covered with fair-sized gum trees which, with the rocks, gave excellent holdfasts, and also over-head power for tackles, which helped us a great deal in lifting and lowering the long skids. Some of the gum trees had to be cut down, and a good deal of the rock blasted in order to give us a firm base for the supports and to place the skids evenly.

I should not have attempted the job had not two splendid skids of Oregon pine 80-feet × 16-inch × 16-inch been available, and also two of 40-feet × 12-inch × 12-inch. The lowering and placing of these long skids gave a great deal more trouble than the gun itself, but gave invaluable instruction to the squad. After we had got our first 80-feet skids properly supported and lashed in position, we got the gun ready to lower by two standing parbuckles of 6-inch rope, and then we met our first and only check. The rope was nearly a new one, but purchased in the Colony, it had been stretched and tested to over eight tons and kept 48 hours on the stretch, yet when the strains of the gun came on it, it stretched again so much that the breech got way on, and, without being able in any way to stop it, I had the mortification of seeing the gun quietly slip down between the skids, and land on the cross-pieces supporting the skids at the first ledge of rock. However, no damage was done beyond breaking one long roller that was in the muzzle and a few short planks. We soon got down to her and got her made fast to the hold-fasts, and then began to clear away ready to start again.

There was a good deal of blasting to do to enable us to slew the muzzle round at right angles. We got her on short skids and placed the 40-feet skids ready to take her down to the next ledge of rock. This was successfully done by one standing parbuckle round the trunnion and preventors at cascable and muzzle. By shifting the 40-feet skids again we got her down half way and then had to get ready for one long descent of 80 feet at 27°, 40 feet at 22°, and about 100 feet of turf at about 14°. We placed the skids close together, cradling, lashing, and supporting them well, that I might lower her down like dismounting to the rear on watered skids. It was rather a hazardous experiment, but it showed the squad what could be done with careful work, good preparation, and the necessary calculations; we fixed the 80-feet skids and cradled them, the top ends by cutting out the rock, the lower ends by placing them in a cradle, cut out of an 8-feet × 12-inch × 12-inch to the proper angles, lashed them well back by chains to strong tree holdfasts, and lashed them together with 2½-inch rope, cutting out recesses on the tops of the skids so that the rope should be even with the skids, supported the skids in four places with stout timbers, kept the cradling with large wedges and dogged the whole together with strong iron dogs.

The 40-feet skids were then butted against the 80-feet, cradled and supported in the same manner, but owing to the nature of the ground with 5° less slope, were supported by the ground itself.

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When the skids were ready the muzzle of the gun was slewed round at right angles so as to get the breech resting on the long skids, then placed the gun on rollers and eased off gradually until the centre of gravity was just on the top of the skids. The centre of a long 4½-inch rope was made fast with a couple of half-hitches to a short roller which was placed in the muzzle of the gun, dividing the squad, well out of danger, on each side. We then cast off the 6-inch rope, which was holding the gun, and with a good heave and a cheer the gun was launched on the skids and went down about 40 miles an hour, pulling up gradually when on the turf till within 4-feet of the lower road in same direction as it started, when the breech touched a stump and slewed the gun round and stopped it in the position desired for going on. Not a single portion of the skidding or supports moved nor did a lashing give way. The total time from top to bottom was 84 hours including bringing up the long skids three-quarters of a mile on two 40-pr. limbers. It was real gunner's work with a considerable spice of danger, but the squad of 25 men worked carefully and bravely, and with the exceptions mentioned above, not another store was expended.

The gun was mounted last Tuesday in the casemate; enclosed are three photographs:[1] one showing the gun ready for launching at the top of the second cliff; the second, the gun in the position as it lay close to lower road; the third, the gun mounted on a temporary sleigh at the entrance to the passage leading to the casemate. There is another gun to come down, but I shall bring it down in a different and by a shorter, but equally interesting way.

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[1] The photographs are preserved at the R.A. Institution, where they can be shown on application being made at the Secretary's office.

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SIACCI'S METHOD OF SOLVING TRAJECTORIES AND PROBLEMS IN BALLISTICS.

BY

A. G. GREENHILL M.A., AND A. G. HADCOCK, R.A.

CONSIDERING that the new method invented by Major F. Siacci, of the Italian Artillery, for solving problems of artillery fire appears to be nearly universally employed on the Continent and in America, we have endeavoured in this paper to introduce this method to British artillerists, by giving a statement of the formulæ used, with a Table and numerical applications, and explaining in what respects the method agrees with and differs from the method, formulæ and tables of Bashforth, Niven, and Sladen, which we have hitherto employed; putting the theoretical explanation and proof of the method last, as Siacci has done.

Siacci's New Method was originally given in the *Giornale d'Artiglieria e Genio, Aprile 1880,* in an article entitled "*Balistica e Pratica,*" and was speedily translated, into French by Captain Priou, in the *Revue d'Artillerie, Octobre 1880,* into Russian by General Mayevski in the *Russian Artillery Journal,* 1881, into German by Captain Wuich in *Mittheilungen über Gegenstande des Artillerie und Genie Wesens, 1881,* and into English by Lieutenant Orin B. Mitcham, Ordnance Department, U.S.A., in *Ordnance Note, 152,* May 1881.

A complete list of the subsequent writings on Siacci's method would be difficult to make; the following may be mentioned:—

"Balistica e Pratica; addizione al nuovo metodo per risolvere i problemè del tiro"; di Francesco Siacci, capitano d'Artigliera. Rome. 1881.

"Revue d'Artillerie," June and August, 1881. Captain Silvestre.

"Ballistic Tables," by H. Langenshold (in Russian). St. Petersburg. 1883.

"Sulla pratica soluzione die problemi del tiro"; di Braccialini Scipione, capitano d'Artiglieria. Roma, 1883.

"Theoretical and Practical Ballistics," Ordnance Note, No. 301; by Lieut. Orin B. Mitcham. 1883.

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"Leichtfassliche Methode zur Losung ballistischen Aufgaben für flache Flugbahnen"; v. Schave, Artillerie Hauptmann. Berlin, 1884.

"Tablas Balisticas;" por D. Juan J. Duran y Loriga, capitan de Artilleria. Coruña, 1886.

"Exterior Ballistics;" by Capt. James M. Ingalls. New York, 1886.

"Lösung der Probleme des direkten und indirekten Schiessens;" von N. Mayevski; übersetzt von Klussmann. Berlin, 1886.

Also articles in the Revue d'Artillerie, 1885, by Vallier; in the Rivista di Artiglieria e Genio, 1886, by Siacci; and in the Swedish Artillerie Tidschrift, 1885.

1. The notation employed in this explanation follows as closely as possible that most commonly used, namely :—

d, the diameter of the projectile in inches.

W, the weight of the projectile in pounds.

V, any initial velocity in feet per second.

v, „ final „ „ „

t, the corresponding time of flight in seconds.

s, „ distance gone in feet.

δ, „ deviation of direction in a vertical plane in degrees.

x, „ horizontal distance advanced in feet.

y, „ vertical distance ascended in feet.

X, „ range in feet on a horizontal plane.

θ, „ inclination of the tangent to the horizon, in circular measure; (so that $\tan\theta = \frac{dy}{dx}$).

ϕ, the angle of departure, in circular measure or degrees.

ω, „ angle of descent.

The general problem we are required to solve in theoretical ballistics is then, for a certain gun, that given d, W and the initial velocity V, and for any one other given condition, either of range s, or elevation ϕ, or time of flight t, &c., to determine all the remaining quantities.

Taking into account the resistance of the air, which is supposed known from Bashforth's experiments, this problem can only be solved in an approximate manner; and for this purpose we require the Ballistic Table, given herewith, the use and construction of which we shall explain as occasion requires.

Given d and W, we must first find $\frac{d^2}{W}$; for it is found experimentally that the resistance of the air at any given velocity is proportional to the cross section of the projectile, that is to d^2, while the retardation is inversely proportional to W; so that at the same velocity the

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retardations of two different projectiles are proportional to the corresponding values of $\frac{d^2}{W}$; the numbers in the Ballistic Table being calculated for a standard projectile in which $\frac{d^2}{W} = 1$.

The quantity $\frac{W}{d^2}$ is called the *sectional density* of the projectile, and sometimes the *ballistic coefficient*, and is denoted by C, so that $\frac{d^2}{W} = \frac{1}{C}$; for instance $C = 1$ if $d = 1$, $W = 1$, giving a projectile in which the diameter is one inch and the weight is one pound, like the Nordenfelt bullet.

2. The formulæ employed by Siacci, which we give here without demonstration, reserving the proofs to the end of this paper, are, for a range X on a horizontal plane, with initial velocity V and final velocity v, angle of elevation ϕ and of descent ω,

$$X = C\{S(V) - S(u)\} \quad \ldots \quad (1)$$

$$\sin 2\phi = 2C\left\{I(V) - \frac{A(V) - A(u)}{S(V) - S(u)}\right\} \quad \ldots \quad (2)$$

$$\tan \omega = C\sec^2\phi\left\{\frac{A(V) - A(u)}{S(V) - S(u)} - I(u)\right\} \quad \ldots \quad (3)$$

or, supposing that on the right hand side, ϕ may be replaced by ω without sensible error,

$$\sin 2\omega = 2C\left\{\frac{A(V) - A(u)}{S(V) - S(u)} - I(u)\right\} \quad \ldots \quad (3a)$$

$$t = C\sec\phi\{T(V) - T(u)\} \quad \ldots \quad (4)$$

and u is connected with the final velocity v by the equation,

$$u = v\cos\omega\sec\phi \quad \ldots \quad (5)$$

Then for a given range X, and given ballistic coefficient C and initial velocity V, equation (1) by means of the Ballistic Table, determines $S(u)$ and therefore u, and then (2) gives the angle of departure ϕ, (3) or (3a) gives the angle of descent ω, and (4) gives t the time of flight.

But if we use v now to denote the remaining velocity at any intermediate point of the trajectory, and if

$$u = v\cos\theta\sec\phi,$$

then Siacci gives the equations

$$\tan\theta = \tan\phi - C\sec^2\phi\{I(V) - I(u)\} \quad \ldots \quad (6)$$

$$\frac{y}{x} = \tan\phi - C\sec^2\phi\left\{I(V) - \frac{A(V) - A(u)}{S(V) - S(u)}\right\} \quad \ldots \quad (7)$$

equation (6) giving θ the inclination of the tangent to the horizon, and equation (7) giving y the vertical height corresponding to x the distance advanced horizontally for any point of the trajectory.

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It must be carefully noticed that in equations (6) and (7) v and u refer to any intermediate point of the trajectory, while in (1), (2), (3), (4) v and u refer to the final point of the trajectory; this ambiguity of notation is customary in the writings we quote from, and will not be found to lead to confusion.

3. These equations of Siacci have been slightly modified by General Mayevski, in order to make the approximation more simple, and are written by him in the form

$$X = C\cos\bar{\phi}\,\{S(U) - S(u)\} \quad \ldots \quad (8)$$

$$\tan\phi = C\sec\bar{\phi}\,\left\{I(U) - \frac{A(U) - A(u)}{S(U) - S(u)}\right\} \quad \ldots \quad (9)$$

$$\tan\omega = C\sec\bar{\phi}\,\left\{\frac{A(U) - A(u)}{S(U) - S(u)} - I(u)\right\} \quad \ldots \quad (10)$$

$$t = C\,\{T(U) - T(u)\} \quad \ldots \quad (11)$$

where

$$\left.\begin{aligned} U &= V\cos\phi\,\sec\bar{\phi}, \\ u &= v\cos\omega\,\sec\bar{\phi}, \end{aligned}\right\} \quad \ldots \quad (12)$$

v denoting the final velocity.

But for any intermediate point of the trajectory, if v now denotes the remaining velocity, and if

$$u = v\cos\theta\sec\bar{\phi} \quad \ldots \quad (13)$$

then

$$\tan\theta = \tan\phi - C\sec\bar{\phi}\,\{I(U) - I(u)\} \quad \ldots \quad (14)$$

$$\frac{y}{x} = \tan\phi - C\sec\bar{\phi}\,\left\{I(U) - \frac{A(U) - A(u)}{S(U) - S(u)}\right\} \quad \ldots \quad (15).$$

Here $\sec\bar{\phi}$ is a quantity, denoted by a by Mayevski, representing the mean value of $\sec\theta$ over the arc of the trajectory considered, so that $\bar{\phi}$ is the mean inclination of the arc, employed by Didion and Niven in calculating trajectories.

4. Very little error is introduced, as pointed out by Siacci, and as we shall subsequently demonstrate, if U and u are replaced by the actual velocities V and v, in trajectories of Direct and Indirect Fire, where the angle of elevation does not exceed 15°; and generally in calculating trajectories in "Direct" and "Indirect or Curved Fire" by means of these formulæ, it is convenient to obtain a first approximate solution of the question, by supposing that $\cos\phi$ and $\cos\bar{\phi}$ on the right hand side of three equations may be replaced by unity, and then we have, from (4) or (11),

$$t = C\,\{T(V) - T(v)\}$$

or

$$\frac{d^2}{W}t = T(V) - T(v) \quad \ldots \quad (16)$$

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and from (1) or (8), replacing X by s,

$$\frac{d^2}{W}s = S(V) - S(v) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (17)$$

and from (6), or (14),

$$\tan\phi - \tan\theta = C\{I(V) - I(v)\}, \quad \ldots \quad \ldots \quad \ldots \quad (18)$$

or, supposing the tangents of the angles ϕ and θ sufficiently small to be replaced by their circular measure,

$$\frac{d^2}{W}(\phi - \theta) = I(V) - I(v),$$

or expressed in degrees,

$$\frac{d^2}{W}(\phi^\circ - \theta^\circ) = D(V) - D(v) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (18a)$$

supposing $$D(v) = \frac{180}{\pi} I(v).$$

On reference to the article on "The Calculation of Trajectories in Direct and Curved Fire," in the Proceedings of the R. A. Institution, Vol. XIII., it will be found that the formulæ there employed are the same as (16), (17), (18a), the function $I(v)$ differing from Mr. Niven's function $D(v)$ by the constant factor $\frac{\pi}{180}$, so that

$$I(v) = \frac{\pi}{180} D(v).$$

5. Supposing p the resistance of the air in pounds to a projectile one-inch in diameter is known by Bashforth's experiments for all values of the velocity v, then $T(v)$, $S(v)$ and $I(v)$ in the Ballistic Table are calculated from the formulæ

$$T(V) - T(v) = \int_v^V \frac{dv}{gp} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (19)$$

$$S(V) - S(v) = \int_v^V \frac{v\,dv}{gp} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (20)$$

$$I(V) - I(v) = \int_v^V \frac{dv}{vp}, \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (21)$$

which are obtained from the consideration of the motion of the standard projectile, for which the ballistic coefficient $C = 1$, supposing it moving in a trajectory which deviates only slightly from a horizontal straight line in consequence of the curving effect of gravity.

But since there is no mathematical expression giving p as a function of v, these integrals (19), (20), and (21) must be calculated by the method of quadratures or approximate integration; denoting by ΔT, ΔS and ΔI the changes of the values of $T(v)$, $S(v)$ and $I(v)$ corresponding to a change Δv of the velocity v, and supposing p to denote the

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average value of the resistance of the air between the velocities v and $v + \Delta v$, say the value corresponding to the velocity $v + \frac{1}{2}\Delta v$, then

$$\Delta T = \frac{\Delta v}{gp}, \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (19a)$$

$$\Delta T = \frac{v\Delta v}{gp} = v\Delta T, \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (20a)$$

$$\Delta I = \frac{\Delta v}{pv} = \frac{g}{v}\Delta T; \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (21a)$$

and these differences being calculated, the values of $T(v)$, $S(v)$ and $I(v)$ are obtained by summation by the Arithmometer.

In the Ballistic Table, the velocity v begins at 400, and proceeds by increments of 10, so that $\Delta v = 10$, and the average value of p in any interval 10 of the velocity was taken as the arithmetic mean of the values of p for the initial and final velocities; thus between the velocities 1000 and 1010 the average value of p was taken as $\frac{1}{2}(2{\cdot}330 + 2{\cdot}404) = 2{\cdot}367$.

6. Formula (7) or (15) giving y the height of the trajectory at any horizontal distance x for any initial velocity V and remaining velocity v, by means of the new function $A(v)$, called the *altitude function*, constitutes the chief novelty and importance of Siacci's method; and from formula (7) or (15) we immediately deduce (2), (3) and (9), (10), giving ϕ the angle of departure and ω the angle of descent for any initial velocity V and final velocity v, required to strike an object of given range and altitude.

From the above equations two useful formulæ can be deduced, namely, from (3) and (6),

$$I(v_0) = \frac{A(V) - A(v)}{S(V) - S(v)}, \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (22)$$

giving v_0, the velocity at the vertex when V the initial velocity and v final velocity are known; and from (7),

$$\tan\phi = \frac{1 - \sqrt{\{1 - 4F(F \pm E)\}}}{2F} \quad \ldots \quad \ldots \quad \ldots \quad (23)$$

where $$F = C\{I(V) - I(v_0)\},$$

and $$E = \frac{y}{x} = \tan\psi,$$

so that ψ is the elevation (or depression) of the object aimed at, thus giving ϕ the requisite elevation of the gun; the upper or lower sign being taken with E, according as the object aimed at is higher or lower than the gun; this formulæ (23) is obtained immediately from (7) by solving it as a quadratic in $\tan\phi$.

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7. The Ballistic Table required in the preceding formulæ was calculated by Mr. Hadcock, and gives the values of $T(v)$, $S(v)$, $D(v)$, $I(v)$, $A(v)$ and their differences ΔT, ΔS, ΔD, ΔI, ΔA for values of the velocity v, proceeding by increments $\Delta v = 10$ over the range of velocity required in practical gunnery, starting from $v = 400$.

The value of p, the resistance in lb. of the air to a one-inch projectile at the corresponding velocity v, is also tabulated; this value of p is derived from Mr. Bashforth's value of K, determined by the experiments of 1878–80, by means of the formula

$$p = \frac{K}{g}\left(\frac{v}{1000}\right)^3.$$

The column of values of p represents therefore the result of experiments independent of any theory on the resistance of the air; and granting the correctness of the values of p, the remaining columns of $T(v)$, $S(v)$, $D(v)$, $I(v)$, $A(v)$ follow as a matter of course by arithmetical calculation.

8. These values of p however refer only to a certain standard shape of projectile experimented with by Mr. Bashforth, one in which the ogival head is described with a radius of one and a half diameters, also to a certain standard density of the air, of 534·22 grains to the cubic foot, and to the value of $g = 32{\cdot}1908$; and when these conditions are satisfied, the ballistic coefficient C may be put equal to $\frac{W}{d^2}$; thus for a one-inch projectile weighing one pound, or for a 3-inch projectile weighing 9 pounds, C would be unity.

But it is important to allow for variations in the shape of the head of the projectile, for the degree of steadiness of the projectile in its flight, and for variations in the density of the air; and it will be found that the necessary corrections can be concentrated into a correction of the value of C, the ballistic coefficient, by putting

$$C = \frac{W}{nd^2},$$

where the factor n, called the *coefficient of reduction*, is composed of the three factors κ, σ, τ, so that

$$n = \kappa\sigma\tau,$$

where κ is the correction for the shape of the projectile, σ for the degree of its steadiness in flight, and τ for the variations of density in the air.

Tables of values of κ, σ, τ, with a corresponding explanation, are given by Mr. Bashforth in his article "On the Use of General Tables to calculate Times of Flight and Remaining Velocities," in the Proceedings of the R. A. Institution, Vol. XIII., No. 10, April, 1885.

An article by Commander H. J. May, R.N., "Notes on the Method of Compiling a Range Table," in the Proceedings of the R. A. Institution, Vol. XIV., No. 10, May, 1886, in its bearing on the subject of coefficients of retardation, must be consulted, and also the works of Siacci, Duran, Mayevski and Ingalls, mentioned above.

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For instance Bashforth's experiments are reduced to a standard density of the air of 534·22 grains per cubic foot, while Krupp takes a standard density of 1·206 kilograms per metre cube, or 527 grains per cubic foot; so that the corresponding correction for density is

$$\tau = 527 \div 534{\cdot}22 = 0{\cdot}986\,;$$

while the correction for the shape of head of Krupp's projectile, struck with a radius of two diameters, compared with Bashforth's standard projectile of one and a half diameters is taken by Mr. Bashforth to be

$$\kappa = 0{\cdot}975\,.$$

A Table of values of the correction factor κ is given by Siacci in "Balistica e Pratica; addizione al nuovo metodo per risolvere i probleme del tiro," Roma, 1881; and by Capitan Juan J. Durán, in "Tablas Balisticas," Coruña, 1886, for different proportions of the projectile.

The factor σ required as a correction for the degree of steadiness of the projectile in its flight is quite empirical, and now with the greatly improved centering obtained with breech-loading may generally be replaced by unity and disregarded.

According to Captain Ingalls (Exterior Ballistics, p. 127) the correction for the density of the air, represented by our factor τ, is obtained by putting

$$\tau = \frac{\delta}{\delta_1},$$

where $$\delta_1 = 534{\cdot}22\,,$$

the standard density of the air in grains per cubic foot, when the temperature is 62° F., and the height of the barometer 30 inches; while

$$\delta = \frac{20{\cdot}212\,b}{1 + {\cdot}002178\,t},$$

the density of the air in grains per cubic foot when the temperature is t° F., and the barometer stands at b inches; so that $\delta = 534{\cdot}22$, when $t = 62$, $b = 30$.

When the height of the trajectory becomes considerable, an important correction in the value of the factor τ is due to the diminished density of the air due to ascending in the atmosphere, obtained from the formula

$$\delta' = \delta e^{-\frac{y}{\lambda}},$$

where δ representing the density of the air at the gun, δ' represents the density of the air at a height of y feet, and then λ, which is the height of the homogeneous atmosphere in feet if the temperature is supposed constant, may be put equal to its mean value 27800.

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9. The values of ΔT, T, ΔS, S, ΔD, D, given in the Ballistic Table are the same as those obtained in the paper on "The Calculation of Trajectories in Direct and Curved Fire," and the manner in which these quantities are deduced from the experimental values of p is there explained.

The values of ΔI and I are obtained from ΔD and D by multiplication by the factor $\frac{\pi}{180}$; or we may obtain ΔI immediately from the formulæ

$$\Delta I = \frac{g}{v} \Delta T,$$

and thence the values of $I(v)$ by summation with the Arithmometer.

Lastly, Siacci's altitude function $A(v)$ is derived by summation from the calculated values of its differences ΔA, obtained from the formula

$$\Delta A = v\, I(v)\, \Delta T.$$

The theoretical explanation of the $A(v)$ function will be given hereafter, at the end of this paper; it is important however to notice that our values of $I(v)$ and $A(v)$ are one-half the values given by Siacci, as adapted to English units by Lieut. Orin B. Mitcham in "Ordnance Note," No. 152, May, 1881; but this factor one-half is allowed for in our formulæ.

10. We are now prepared to apply the Ballistic Table to the solution of practical problems in gunnery.

A collection of elementary examples, illustrating the use of the columns $T(v)$, $S(v)$, and $D(v)$ has been already given in the article on "The Calculation of Trajectories in Direct and Curved Fire," in the "Proceedings of the R. A. Institution," Vol. XIII.; and we shall now proceed to illustrate the use of the additional columns $I(v)$ and $A(v)$ by employing them in Siacci's and Mayevski's formulæ given above, for the solution of gunnery problems of a somewhat more complicated nature.

These examples have received the benefit of a revision by Lieut.-Colonel H. W. L. Hime, R. A., to whom many valuable suggestions and criticisms are due.

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BALLISTIC TABLE.

v	p	ΔT	T	ΔS	S	ΔD	D	ΔI	I	ΔA	A
400	·2943	1·0268	0·0000	415·87	000·00						
410	·3110	·9723	1·0268	403·50	415·87						
420	·3280	·9226	1·9991	392·09	819·37						
430	·3453	·8772	2·9217	381·57	1211·46						
440	·3630	·8350	3·7989	371·59	1593·03						
450	·3810	·7964	4·6339	362·37	1964·62						
460	·3992	·7610	5·4303	353·85	2326·99						
470	·4174	·7278	6·1913	345·72	2679·84						
480	·4360	·6973	6·9191	338·21	3025·56						
490	·4547	·6692	7·6164	331·27	3363·77						
500	·4734	·6433	8·2856	324·87	3694·04	2·3495	·0000	·04101	·00000	·00	·00
510	·4928	·6183	8·9289	318·45	4018·91	2·2145	2·3495	·03865	·04101	13·06	·00
520	·5124	·5952	9·5472	312·50	4337·36	2·0912	4·5640	·03650	·07966	24·89	13·06
530	·5318	·5733	10·1424	306·74	4649·86	1·9766	6·6552	·03450	·11616	35·63	37·95
540	·5517	·5526	10·7157	301·14	4956·60	1·8699	8·6318	·03264	·15066	45·37	73·58
550	·5721	·5332	11·2683	295·94	5257·74	1·7721	10·5017	·03093	·18330	54·25	118·95
560	·5931	·5148	11·8015	290·86	5553·68	1·6805	12·2738	·02933	·21423	62·31	173·20
570	·6139	·4977	12·3163	286·15	5844·54	1·5963	13·9543	·02786	·24356	69·69	235·51
580	·6339	·4821	12·8140	282·05	6130·69	1·5201	15·5506	·02653	·27142	76·55	305·20
590	·6539	·4677	13·2961	278·32	6412·74	1·4495	17·0707	·02530	·29795	82·92	381·75
600	·6743	·4539	13·7638	274·58	6691·06	1·3836	18·5202	·02415	·32325	88·76	464·67
610	·6952	·4400	14·2177	270·62	6965·64	1·3197	19·9038	·02303	·34740	94·01	553·43
620	·7166	·4271	14·6577	266·95	7236·26	1·2604	21·2235	·02200	·37043	98·88	647·44
630	·7386	·4142	15·0848	262·99	7503·21	1·2030	22·4839	·02100	·39243	103·21	746·32
640	·7615	·4020	15·4990	259·30	7766·20	1·1496	23·6869	·02006	·41343	107·20	849·53
650	·7840	·3902	15·9010	255·58	8025·50	1·0987	24·8365	·01918	·43349	110·79	956·73
660	·8081	·3787	16·2912	251·81	8281·08	1·0503	25·9352	·01833	·45267	113·99	1067·52
670	·8325	·3678	16·6699	248·28	8532·89	1·0051	26·9855	·01754	·47100	116·94	1181·51
680	·8565	·3576	17·0377	244·96	8781·17	·9629	27·9906	·01681	·48854	119·67	1298·45
690	·8807	·3480	17·3953	241·86	9026·13	·9235	28·9535	·01612	·50535	122·22	1418·12
700	·9048	·3385	17·7433	238·67	9267·99	·8857	29·8770	·01546	·52147	124·46	1540·34
710	·9306	·3292	18·0818	235·39	9506·66	·8492	30·7627	·01482	·53693	126·39	1664·80
720	·9577	·3196	18·4110	231·73	9742·05	·8131	31·6119	·01419	·55175	127·86	1791·19
730	·9861	·3105	18·7306	228·25	9973·78	·7793	32·4250	·01360	·56594	129·17	1919·05
740	1·0146	·3019	19·0411	224·93	10202·03	·7475	33·2043	·01305	·57954	130·36	2048·22
750	1·0433	·2938	19·3430	221·78	10426·96	·7176	33·9518	·01253	·59259	131·43	2178·58
760	1·0733	·2853	19·6368	218·23	10648·74	·6878	34·6694	·01200	·60512	132·06	2310·01
770	1·1062	·2765	19·9221	214·28	10866·97	·6580	35·3572	·01148	·61712	132·24	2442·07
780	1·1408	·2681	20·1986	210·48	11081·25	·6300	36·0152	·01100	·62860	132·31	2574·31
790	1·1764	·2602	20·4667	206·83	11291·73	·6036	36·6452	·01053	·63960	132·29	2706·62
800	1·2119	·2526	20·7269	203·31	11498·56	·5787	37·2488	·01010	·65013	132·18	2838·91
810	1·248	·2450	20·9795	199·67	11701·87	·5544	37·8275	·00968	·66023	131·83	2971·09
820	1·288	·2371	21·2245	195·64	11901·54	·5302	38·3819	·00925	·66991	131·06	3102·93
830	1·334	·2290	21·4616	191·23	12097·18	·5047	38·9121	·00881	·67916	129·88	3233·98
840	1·381	·2210	21·6906	186·73	12288·41	·4824	39·4168	·00842	·68797	128·47	3363·86
850	1·431	·2133	21·9116	182·39	12475·14	·4602	39·8992	·00803	·69639	127·02	3492·33
860	1·482	·2060	22·1249	178·20	12657·53	·4393	40·3594	·00767	·70442	125·53	3619·35
870	1·534	·1990	22·3309	174·15	12835·73	·4195	40·7987	·00732	·71209	124·01	3744·88
880	1·588	·1924	22·5299	170·24	13009·88	·4009	41·2182	·00700	·71941	122·47	3868·89
890	1·643	·1860	22·7223	166·43	13180·12	·3833	41·6191	·00669	·72641	120·91	3991·36
900	1·699	·1799	22·9083	162·80	13346·55	·3668	42·0024	·00640	·73310	119·35	4112·27
910	1·756	·1741	23·0882	159·26	13509·35	·3508	42·3690	·00612	·73950	117·77	4231·62
920	1·814	·1685	23·2623	155·83	13668·61	·3359	42·7198	·00586	·74562	116·19	4349·39
930	1·874	·1631	23·4308	152·52	13824·44	·3218	43·0557	·00562	·75148	114·61	4465·58
940	1·935	·1580	23·5939	149·31	13976·96	·3091	43·3775	·00538	·75710	113·04	4580·19
950	1·998	·1531	23·7519	146·20	14126·27	·2957	43·6866	·00516	·76248	111·47	4693·23

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BALLISTIC TABLE.—*Continued.*

v	*p*	Δ*T*	*T*	Δ*S*	*S*	Δ*D*	*D*	Δ*I*	*I*	Δ*A*	*A*
960	2·061	·1484	23·9050	143·18	14272·47	·2836	43·9823	·00495	·76764	109·91	4804·70
970	2·127	·1439	24·0534	140·26	14415·65	·2721	44·2659	·00475	·77259	108·36	4914·61
980	2·193	·1395	24·1973	137·43	14555·91	·2613	44·5380	·00456	·77734	106·83	5022·97
990	2·261	·1354	24·3368	134·68	14693·34	·2509	44·7993	·00438	·78190	105·30	5129·80
1000	2·330	·1314	24·4722	132·01	14828·02	·2411	45·0502	·00421	·78628	103·80	5235·10
1010	2·404	·1272	24·6036	129·08	14960·03	·2311	45·2913	·00403	·79049	102·03	5338·90
1020	2·482	·1227	24·7308	125·74	15089·11	·2207	45·5224	·00385	·79452	99·90	5440·93
1030	2·604	·1150	24·8535	119·07	15214·85	·2050	45·7431	·00358	·79837	95·06	5540·83
1040	2·823	·1046	24·9685	109·28	15333·92	·1846	45·9481	·00322	·80195	87·63	5635·89
1050	3·139	·0938	25·0731	98·95	15443·20	·1640	46·1327	·00286	·80517	79·67	5723·52
1060	3·478	·0857	25·1669	91·27	15542·15	·1484	46·2967	·00258	·80803	73·75	5803·19
1070	3·756	·0800	25·2526	86·02	15633·42	·1373	46·4451	·00240	·81061	69·73	5876·94
1080	3·999	·0755	25·3326	81·91	15719·44	·1283	46·5824	·00224	·81301	66·80	5946·67
1090	4·221	·0719	25·4081	78·75	15801·35	·1211	46·7107	·00211	·81525	64·20	6013·27
1100	4·420	·0688	25·4800	75·97	15880·10	·1148	46·8318	·00200	·81736	62·10	6077·47
1110	4·605	·0663	25·5488	73·93	15956·07	·1097	46·9468	·00191	·81936	60·58	6139·57
1120	4·766	·0641	25·6151	72·16	16030·00	·1052	47·0563	·00184	·82127	59·26	6200·15
1130	4·913	·0624	25·6792	70·83	16102·16	·1014	47·1615	·00177	·82311	58·30	6259·41
1140	5·041	·0608	25·7418	69·60	16172·99	·0979	47·2629	·00171	·82488	57·41	6317·71
1150	5·179	·0592	25·8024	68·40	16242·59	·0946	47·3608	·00165	·82659	56·53	6375·12
1160	5·315	·0577	25·8616	67·23	16310·99	·0914	47·4554	·00159	·82824	55·68	6431·65
1170	5·454	·0562	25·9193	66·09	16378·22	·0883	47·5468	·00154	·82983	54·84	6487·33
1180	5·594	·0548	25·9755	64·98	16444·31	·0853	47·6351	·00149	·83137	54·02	6542·17
1190	5·738	·0535	26·0303	63·89	16509·29	·0825	47·7204	·00144	·83286	53·21	6596·19
1200	5·884	·0522	26·0838	62·84	16573·18	·0798	47·8029	·00139	·83430	52·43	6649·40
1210	6·032	·0509	26·1360	61·81	16636·02	·0772	47·8827	·00135	·83569	51·65	6701·83
1220	6·183	·0496	26·1869	60·80	16697·83	·0747	47·9599	·00130	·83704	50·89	6753·48
1230	6·331	·0485	26·2365	59·88	16758·63	·0724	48·0346	·00126	·83834	50·20	6804·37
1240	6·486	·0473	26·2850	58·92	16818·51	·0701	48·1070	·00122	·83960	49·47	6854·57
1250	6·637	·0462	26·3323	58·04	16877·43	·0680	48·1771	·00119	·84082	48·80	6904·04
1260	6·791	·0452	26·3785	57·17	16935·47	·0659	48·2451	·00115	·84201	48·14	6952·84
1270	6·948	·0442	26·4237	56·38	16992·64	·0640	48·3110	·00112	·84316	47·54	7000·98
1280	7·101	·0433	26·4679	55·61	17049·02	·0621	48·3750	·00108	·84428	46·95	7048·52
1290	7·256	·0424	26·5112	54·86	17104·63	·0603	48·4371	·00105	·84536	46·37	7095·47
1300	7·413	·0415	26·5536	54·12	17159·49	·0586	48·4974	·00102	·84641	45·81	7141·84
1310	7·569	·0406	26·5951	53·45	17213·61	·0570	48·5560	·000995	·84743	45·29	7187·65
1320	7·723	·0398	26·6357	52·79	17267·08	·0555	48·6130	·000968	·848425	44·79	7232·94
1330	7·879	·0391	26·6755	52·15	17319·85	·0540	48·6685	·000942	·849393	44·29	7277·73
1340	8·034	·0383	26·7146	51·52	17372·00	·0525	48·7225	·000917	·850335	43·81	7322·02
1350	8·185	·0376	26·7529	50·95	17423·52	·0512	48·7750	·000893	·851252	43·37	7365·83
1360	8·339	·0369	26·7905	50·39	17474·47	·0499	48·8262	·000871	·852145	42·94	7409·20
1370	8·490	·0363	26·8274	49·90	17524·86	·0487	48·8761	·000850	·853016	42·56	7452·14
1380	8·639	·0357	26·8637	49·41	17574·76	·0476	48·9248	·000830	·853866	42·19	7494·70
1390	8·784	·0351	26·8994	48·94	17624·17	·0464	48·9723	·000810	·854696	41·83	7536·89
1400	8·924	·0345	26·9345	48·52	17673·11	·0453	49·0187	·000791	·855506	41·51	7578·72
1410	9·066	·0340	26·9690	48·12	17721·63	·0443	49·0640	·000774	·856297	41·20	7620·23
1420	9·206	·0335	27·0030	47·72	17769·75	·0433	49·1083	·000757	·857071	40·90	7661·43
1430	9·340	·0330	27·0365	47·33	17817·47	·0424	49·1516	·000740	·857828	40·60	7702·33
1440	9·489	·0325	27·0695	47·00	17864·80	·0415	49·1940	·000725	·858568	40·35	7742·93
1450	9·622	·0321	27·1020	46·68	17911·80	·0407	49·2355	·000710	·859293	40·11	7783·28
1460	9·753	·0317	27·1341	46·36	17958·48	·0398	49·2762	·000695	·860003	39·85	7823·39
1470	9·879	·0313	27·1658	46·10	18004·84	·0391	49·3160	·000682	·860698	39·68	7863·24
1480	10·013	·0309	27·1971	45·80	18050·94	·0383	49·3551	·000669	·861380	39·46	7902·92
1490	10·133	·0305	27·2280	45·52	18096·74	·0376	49·3934	·000656	·862049	39·24	7942·38
1500	10·263	·0301	27·2585	45·28	18142·26	·0369	49·4310	·000644	·862705	39·07	7981·62
1510	10·384	·0298	27·2886	45·10	18187·54	·0362	49·4679	·000633	·863349	38·94	8020·69
1520	10·493	·0295	27·3184	44·93	18232·64	·0356	49·5041	·000622	·863982	38·82	8059·63
1530	10·601	·0292	27·3479	44·77	18277·57	·0350	49·5397	·000612	·864604	38·71	8098·45
1540	10·712	·0289	27·3771	44·57	18322·34	·0344	49·5747	·000601	·865216	38·56	8137·16
1550	10·829	·0285	27·4060	44·37	18366·91	·0339	49·6091	·000591	·865817	38·42	8175·72
1560	10·945	·0282	27·4345	44·19	18411·28	·0333	49·6430	·000581	·866408	38·28	8214·14
1570	11·060	·0279	27·4627	44·01	18455·47	·0327	49·6763	·000571	·866989	38·16	8252·42

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BALLISTIC TABLE.—*Continued.*

v	*p*	Δ*T*	*T*	Δ*S*	*S*	Δ*D*	*D*	Δ*I*	*I*	Δ*A*	*A*
1580	11·175	·0277	27·4906	43·84	18499·48	·0322	49·7090	·000562	·867560	38·03	8290·58
1590	11·288	·0274	27·5183	43·68	18543·32	·0317	49·7412	·000553	·868122	37·92	8328·61
1600	11·416	·0271	27·5457	43·47	18587·00	·0311	49·7729	·000543	·868675	37·76	8366·53
1610	11·540	·0268	27·5728	43·27	18630·47	·0306	49·8040	·000534	·869218	37·61	8404·29
1620	11·662	·0265	27·5996	43·08	18673·74	·0301	49·8349	·000525	·869752	37·47	8441·90
1630	11·784	·0262	27·6261	42·90	18716·82	·0296	49·8647	·000517	·870277	37·33	8479·37
1640	11·909	·0260	27·6523	42·72	18759·72	·0291	49·8943	·000508	·870794	37·20	8516·70
1650	12·030	·0257	27·6783	42·55	18802·44	·0287	49·9234	·000500	·871302	37·08	8553·90
1660	12·150	·0255	27·7040	42·39	18844·99	·0282	49·9521	·000492	·871802	36·95	8590·98
1670	12·268	·0252	27·7295	42·18	18887·38	·0277	49·9803	·000484	·872294	36·79	8627·93
1680	12·404	·0249	27·7547	41·98	18929·56	·0273	50·0080	·000476	·872778	36·64	8664·72
1690	12·536	·0247	27·7796	41·78	18971·54	·0268	50·0353	·000468	·873254	36·49	8701·36
1700	12·666	·0244	27·8043	41·60	19013·32	·0264	50·0621	·000461	·873722	36·34	8737·85
1710	12·801	·0242	27·8287	41·41	19054·92	·0260	50·0885	·000453	·874183	36·20	8774·19
1720	12·900	·0239	27·8529	41·23	19096·33	·0256	50·1145	·000446	·874636	36·07	8810·39
1730	13·059	·0237	27·8768	41·06	19137·56	·0252	50·1401	·000439	·875082	35·93	8846·46
1740	13·191	·0234	27·9005	40·90	19178·62	·0248	50·1653	·000432	·875521	35·81	8882·39
1750	13·318	·0232	27·9239	40·69	19219·52	·0244	50·1901	·000425	·875953	35·64	8918·20
1760	13·466	·0230	27·9471	40·53	19260·21	·0240	50·2145	·000419	·876378	35·52	8953·84
1770	13·591	·0227	27·9701	40·33	19300·74	·0236	50·2385	·000412	·876797	35·38	8989·36
1780	13·733	·0225	27·9928	40·19	19341·07	·0233	50·2621	·000406	·877209	35·25	9024·72
1790	13·862	·0223	28·0153	40·00	19381·26	·0229	50·2854	·000400	·877615	35·10	9059·97
1800	14·002	·0221	28·0376	39·81	19421·26	·0225	50·3083	·000393	·878015	34·95	9095·07
1810	14·140	·0219	28·0597	39·68	19461·07	·0222	50·3308	·000388	·878408	34·96	9130·02
1820	14·269	·0217	28·0816	39·51	19500·75	·0219	50·3530	·000382	·878796	34·72	9164·88
1830	14·414	·0214	28·1033	39·34	19540·26	·0216	50·3749	·000376	·879178	34·58	9199·60
1840	14·552	·0212	28·1247	39·17	19579·60	·0212	50·3965	·000370	·879554	34·45	9234·18
1850	14·690	·0210	28·1459	39·01	19618·77	·0209	50·4177	·000365	·879924	34·32	9268·63
1860	14·832	·0209	28·1669	38·90	19657·78	·0206	50·4386	·000360	·880289	34·25	9302·95
1870	14·949	·0207	28·1878	38·75	19696·68	·0203	50·4592	·000355	·880649	34·13	9337·20
1880	15·090	·0205	28·2085	38·61	19735·43	·0200	50·4795	·000350	·881004	34·01	9371·33
1890	15·224	·0203	28·2290	38·46	19774·04	·0198	50·4995	·000345	·881354	33·90	9405·34
1900	15·364	·0201	28·2493	38·32	19812·50	·0195	50·5193	·000340	·881699	33·79	9439·24
1910	15·496	·0199	28·2694	38·19	19850·82	·0192	50·5388	·000335	·882039	33·69	9473·03
1920	15·656	·0197	28·2893	38·01	19889·01	·0189	50·5580	·000330	·882374	33·54	9506·72
1930	15·809	·0196	28·3090	37·83	19927·02	·0186	50·5769	·000325	·882704	33·39	9540·26
1940	15·968	·0194	28·3286	37·66	19964·85	·0184	50·5955	·000320	·883029	33·25	9573·65
1950	16·127	·0192	28·3480	37·48	20002·51	·0181	50·6139	·000316	·883349	33·11	9606·90
1960	16·302	·0190	28·3672	37·26	20039·99	·0178	50·6320	·000311	·883665	32·93	9640·01
1970	16·484	·0187	28·3862	36·99	20077·25	·0175	50·6498	·000305	·883976	32·70	9672·94
1980	16·689	·0185	28·4049	36·73	20114·24	·0172	50·6673	·000300	·884281	32·48	9705·64
1990	16·888	·0183	28·4234	36·47	20150·97	·0169	50·6845	·000295	·884581	32·26	9738·12
2000	17·096	·0181	28·4417	36·21	20187·44	·0166	50·7014	·000290	·884876	32·04	9770·38
2010	17·305	·0178	28·4598	35·95	20223·65	·0163	50·7180	·000285	·885166	31·83	9802·42
2020	17·515	·0176	28·4776	35·65	20259·60	·0160	50·7343	·000280	·885451	31·57	9834·25
2030	17·752	·0174	28·4952	35·35	20295·25	·0158	50·7503	·000275	·885731	31·32	9865·82
2040	17·990	·0171	28·5126	35·06	20330·60	·0155	50·7661	·000270	·886006	31·07	9897·14
2050	18·229	·0169	28·5297	34·77	20365·66	·0152	50·7816	·000265	·886276	30·83	9928·21
2060	18·463	·0167	28·5466	34·49	20400·43	·0149	50·7968	·000260	·886541	30·57	9959·03
2070	18·706	·0165	28·5633	34·21	20434·92	·0147	50·8117	·000256	·886801	30·33	9989·60
2080	18·978	·0163	28·5798	33·93	20469·13	·0144	50·8264	·000251	·887057	30·10	10019·93
2090	19·227	·0160	28·5961	33·60	20503·06	·0141	50·8408	·000247	·887308	29·82	10050·03
2100	19·504	·0158	28·6121	33·34	20536·66	·0139	50·8549	·000242	·887555	29·59	10079·85
2110	19·755	·0156	28·6279	33·02	20570·00	·0136	50·8688	·000238	·887797	29·32	10109·44
2120	20·010	·0154	28·6435	32·76	20603·02	·0134	50·8824	·000234	·888035	29·09	10138·76
2130	20·294	·0152	28·6589	32·50	20635·78	·0132	50·8958	·000230	·888269	28·87	10167·85
2140	20·551	·0150	28·6741	32·25	20668·28	·0129	50·9090	·000226	·888499	28·65	10196·72
2150	20·811	·0149	28·6891	32·00	20700·53	·0127	50·9219	·000222	·888725	28·44	10225·37
2160	21·072	·0147	28·7040	31·75	20732·53	·0125	50·9346	·000218	·888947	28·22	10253·81
2170	21·336	·0145	28·7187	31·46	20764·28	·0123	50·9471	·000214	·889165	27·97	10282·03
2180	21·633	·0143	28·7332	31·22	20795·74	·0121	50·9594	·000211	·889378	27·76	10310·00
2190	21·889	·0141	28·7475	30·98	20826·96	·0119	50·9715	·000207	·889590	27·56	10337·76

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BALLISTIC TABLE.—*Continued.*

v	p	ΔT	T	ΔS	S	ΔD	D	ΔI	I	ΔA	A
2200	22·158	·0139	28·7616	30·74	20857·94	·0117	50·9834	·000204	·889797	27·36	10365·32
2210	22·429	·0138	28·7755	30·51	20888·68	·0115	50·9951	·000200	·890001	27·17	10392·68
2220	22·702	·0136	28·7893	30·23	20919·19	·0113	51·0066	·000197	·890201	26·92	10419·85
2230	23·010	·0134	28·8029	30·01	20949·42	·0111	51·0179	·000193	·890398	26·72	10446·77
2240	23·288	·0133	28·8163	29·79	20979·43	·0109	51·0290	·000190	·890591	26·53	10473·49
2250	23·566	·0131	28·8296	29·53	21009·22	·0107	51·0399	·000187	·890781	26·30	10500·02
2260	23·848	·0130	28·8427	29·31	21038·75	·0105	51·0506	·000184	·890968	26·12	10526·32
2270	24·132	·0128	28·8557	29·14	21068·06	·0104	51·0611	·000181	·891152	25·97	10552·44
2280	24·368	·0127	28·8685	28·98	21097·20	·0102	51·0715	·000179	·891333	25·83	10578·41
2290	24·583	·0126	28·8812	28·90	21126·18	·0101	51·0817	·000177	·891512	25·76	10604·24
2300	24·760	·0125	28·8938	28·82	21155·08	·0100	51·0918	·000175	·891689	25·70	10630·00
2310	24·887	·0125	28·9063	28·84	21183·90	·0099	51·1018	·000173	·891864	25·72	10655·70
2320	24·987	·0124	28·9188	23·85	21212·74	·0098	51·1117	·000172	·892037	25·74	10681·42
2330	25·071	·0124	28·9312	28·88	21241·59	·0098	51·1215	·000171	·892209	25·77	10707·16
2340	25·152	·0123	28·9436	28·91	21270·47	·0097	51·1313	·000169	·892380	25·80	10732·93
2350	25·242	·0123	28·9559	28·94	21299·38	·0096	51·1410	·000168	·892549	25·83	10758·73
2360	25·316	·0123	28·9682	28·98	21328·32	·0096	51·1506	·000167	·892717	25·87	10784·56
2370	25·386	·0122	28·9805	29·02	21357·30	·0095	51·1602	·000166	·892884	25·91	10810·43
2380	25·467	·0122	28·9927	29·06	21386·32	·0094	51·1697	·000165	·893050	25·95	10836·34
2390	25·529	·0122	29·0049	29·10	21415·38	·0094	51·1791	·000163	·893215	26·00	10862·29
2400	25·588	·0121	29·0171	29·16	21444·48	·0093	51·1885	·000162	·893378	26·05	10888·29
2410	25·658	·0121	29·0292	29·21	21473·64	·0092	51·1978	·000161	·893540	26·10	10914·34
2420	25·710	·0121	29·0413	29·27	21502·85	·0092	51·2070	·000160	·893701	26·16	10940·44
2430	25·772	·0121	29·0534	29·33	21532·12	·0091	51·2162	·000159	·893861	26·22	10966·60
2440	25·814	·0120	29·0655	29·35	21561·45	·0091	51·2253	·000158	·894020	26·24	10992·82
2450	25·898	·0120	29·0775	29·37	21590·80	·0090	51·2344	·000157	·894178	26·26	11019·08
2460	26·008	·0119	29·0895	29·39	21620·17	·0089	51·2434	·000156	·894335	26·28	11045·32
2470	26·071	·0119	29·1014	29·41	21649·56	·0089	51·2523	·000155	·894491	26·31	11071·60
2480	26·158	·0119	29·1133	29·44	21678·97	·0088	51·2612	·000154	·894646	26·34	11097·91
2490	26·276	·0118	29·1252	29·42	21708·41	·0087	51·2700	·000152	·894800	26·33	11124·25
2500	26·406	·0117	29·1370	29·40	21737·83	·0086	51·2787	·000151	·894952	26·31	11150·58
2510	26·534	·0117	29·1487	29·39	21767·23	·0086	51·2873	·000150	·895103	26·30	11176·89
2520	26·709	·0116	29·1604	29·32	21796·62	·0085	51·2959	·000148	·895253	26·25	11203·19
2530	26·866	·0115	29·1720	29·25	21825·94	·0084	51·3044	·000147	·895401	26·19	11229·44
2540	27·039	·0115	29·1835	29·13	21855·19	·0083	51·3128	·000145	·895548	26·09	11255·63
2550	27·243	·0114	29·1950	29·01	21884·32	·0082	51·3211	·000143	·895693	25·99	11281·72
2560	27·464	·0112	29·2064	28·84	21913·33	·0081	51·3293	·000141	·895836	25·84	11307·71
2570	27·736	·0111	29·2176	28·67	21942·17	·0080	51·3374	·000139	·895977	25·69	11333·55
2580	28·010	·0110	29·2287	28·50	21970·84	·0079	51·3454	·000137	·896116	25·54	11359·24
2590	28·337	·0109	29·2397	28·29	21999·34	·0077	51·3533	·000136	·896253	25·35	11384·78
2600	28·613	·0108	29·2506	28·12	22027·63	·0076	51·3610	·000133	·896388	25·21	11410·13
2610	28·945	·0107	29·2614	27·91	22055·75	·0075	51·3686	·000131	·896521	25·02	11435·34
2620	29·279	·0106	29·2721	27·70	22083·66	·0074	51·3761	·000129	·896652	24·83	11460·36
2630	29·562	·0105	29·2827	27·54	22111·36	·0073	51·3835	·000128	·896781	24·70	11485·19
2640	29·899	·0103	29·2932	27·33	22138·90	·0072	51·3908	·000126	·896909	24·51	11509·89
2650	30·241	·0102	29·3035	27·18	22166·23	·0071	51·3980	·000124	·897035	24·38	11534·40
2660	30·527	·0101	29·3137	26·97	22193·41	·0070	51·4051	·000122	·897159	24·20	11558·78
2670	30·873	·0100	29·3238	26·77	22220·38	·0069	51·4121	·000120	·997281	24·02	11582·98
2680	31·221	·0099	29·3338	26·62	22247·15	·0068	51·4190	·000119	·897401	23·89	11607·00
2690	31·494	·0098	29·3437	26·43	22273·77	·0067	51·4258	·000117	·867520	23·72	11630·89
2700	31·846	·0097	29·3535	26·23	22300·20	·0066	51·4325	·000115	·897637	23·55	11654·61
2710	32·203	·0096	29·3632	26·09	22326·43	·0065	51·4391	·000114	·897752	23·42	11678·16
2720	32·500	·0095	29·3726	25·90	22352·52	·0064	51·4456	·000112	·897866	23·25	11701·58
2730	32·859	·0094	29·3823	25·71	22378·42	·0063	51·4520	·000111	·897978	23·09	11724·83
2740	33·222	·0093	29·3917	25·52	22404·13	·0062	51·4583	·000109	·898089	22·92	11747·92
2750	33·586	·0092	29·4010	25·34	22429·65	·0062	51·4645	·000108	·898198	22·76	11770·84
2760	33·955	·0091	29·4102	25·15	22454·99	·0061	51·4707	·000106	·898306	22·60	11793·60
2770	34·325	·0090	29·4193	24·97	22480·14	·0060	51·4768	·000104	·898412	22·44	11816·20
2780	34·697	·0089	29·4283	24·79	22505·11	·0059	51·4828	·000103	·898516	22·29	11838·64
2790	35·073	·0088	29·4372	24·62	22529·90	·0058	51·4887	·000101	·898619	22·12	11860·93
2800	35·453	·0087	29·4460	24·32	22554·52	·0057	51·4945	·000099	·898720	21·96	11883·05

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EXAMPLES OF THE USE OF SIACCI'S METHOD.

Ex. 1. Firing, on the same level as the target, with the 12-pr. B.L. gun at 2000 yards range, it is required to know at what height a shrapnel shell will be if burst 200, 150, 100, and 50 yards short; also the angle of descent at each point and at the end of the range.

Here $d = 3$, $W = 12{\cdot}31$, $V = 1710$, $s = 6000$ are given, and it is required to find y, θ, and ω.

Let us take a coefficient of reduction $n = {\cdot}87$; then since $C = \frac{W}{nd^2}$,

$$\log d = \ {\cdot}47712,$$
$$\log d^2 = \ {\cdot}95424,$$
$$\log n = \bar{1}{\cdot}93952,$$
$$\log nd^2 = \ {\cdot}89376,$$
$$\log W = 1{\cdot}09026,$$
$$\log C = \ {\cdot}19650,$$
$$C = 1{\cdot}572.$$

Denote by s_1, s_2, s_3, s_4, and s, the distances in feet, v_1, v_2, v_3, v_4 and v the velocities at 1800, 1850, 1900, 1950 and 2000 yards respectively; then employing formula (1) or (17), and replacing u by v,

$$s_1 = \ 5400,$$
$$\log s_1 = 3{\cdot}73239,$$
$$\log C = \ {\cdot}19650.$$
$$\log \frac{s_1}{C} = 3{\cdot}53589,$$
$$\frac{s_1}{C} = \ 3434{\cdot}78,$$

and, from the Ballistic Table,

$$S(V) = 19054{\cdot}92,$$
$$S(v_1) = 15620{\cdot}14,$$
$$v_1 = \ 1068{\cdot}5.$$

Similarly

$$S(v_2) = 15524{\cdot}73, \quad v_2 = 1058{\cdot}2;$$
$$S(v_3) = 15429{\cdot}32, \quad v_3 = 1048{\cdot}7;$$
$$S(v_4) = 15333{\cdot}91, \quad v_4 = 1040;$$
$$S(v) = 15238{\cdot}50, \quad v = 1032.$$

We have now to obtain the angle of elevation ϕ for 2000 yards range, employing formula (2) and using v for u;

$$A(V) = 8774{\cdot}19$$
$$A(v) = 5559{\cdot}84$$
$$\therefore \quad A(V) - A(v) = 3214{\cdot}35$$
$$S(V) = 19054{\cdot}92$$
$$S(v) = 15238{\cdot}50$$
$$\therefore \quad S(V) - S(v) = 3816{\cdot}42$$
$$\log \{A(V) - A(v)\} = 3{\cdot}50709$$
$$\log \{S(V) - S(v)\} = 3{\cdot}58166$$

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$$\therefore \log \frac{A(V)-A(v)}{S(V)-S(v)} = \bar{1}\cdot 92543$$

$$\frac{A(V)-A(v)}{S(V)-S(v)} = \cdot 842230$$

$$I(V) = \cdot 874183$$

$$\therefore I(V) - \frac{A(V)-A(v)}{S(V)-S(v)} = \cdot 031953$$

$$\log\left\{I(V) - \frac{A(V)-A(v)}{S(V)-S(v)}\right\} = \bar{2}\cdot 50451$$

$$\log C = \cdot 19650$$

$$\log 2 = \cdot 30103$$

$$\therefore \quad L \sin 2\phi = 9\cdot 00204$$

$$2\phi = 5^\circ\ 46'$$

$$\phi = 2^\circ\ 53'.$$

To determine the height corresponding to v_1 from formula (7),

$$A(V) = 8774\cdot 19$$

$$A(v_1) = 5865\cdot 88$$

$$\therefore \quad A(V) - A(v_1) = 2908\cdot 31$$

$$S(V) = 19054\cdot 92$$

$$S(v_1) = 15620\cdot 142$$

$$\therefore \quad S(V) - S(v_1) = 3434\cdot 778$$

$$\log\{A(V) - A(v_1)\} = 3\cdot 46364$$

$$\log\{S(V) - S(v_1)\} = 3\cdot 53590$$

$$\therefore \log \frac{A(V)-A(v_1)}{S(V)-S(v_1)} = \bar{1}\cdot 92774,$$

$$\frac{A(V)-A(v_1)}{S(V)-S(v_1)} = \cdot 846720,$$

$$I(V) = \cdot 874183,$$

$$\therefore I(V) - \frac{A(V)-A(v_1)}{S(V)-S(v_1)} = \cdot 027463,$$

$$\log\left\{I(V) - \frac{A(V)-A(v_1)}{S(V)-S(v_1)}\right\} = \bar{2}\cdot 43875,$$

$$2L \sec\phi = 10\cdot 00110,$$

$$\log C = \cdot 19650,$$

$$\therefore \log C \sec^2\phi \left\{I(V) - \frac{A(V)-A(v_1)}{S(V)-S(v_1)}\right\} = \bar{2}\cdot 63635,$$

$$C\sec^2\phi \left\{I(V) - \frac{A(V)-A(v_1)}{S(V)-S(v_1)}\right\} = \cdot 043286,$$

$$\tan\phi = \cdot 050366,$$

$$\therefore \quad \frac{y_1}{x_1} = \cdot 007080,$$

$$\log \frac{y_1}{x_1} = \bar{3}\cdot 85003,$$

$$\log x_1 = 3\cdot 73239,$$

$$\therefore \quad \log y_1 = 1\cdot 58242,$$

$$y_1 = 38\cdot 23.$$

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Similarly

$$y_2 = 30{\cdot}04\,,$$
$$y_3 = 21{\cdot}00\,,$$
$$y_4 = 10{\cdot}64\,.$$

Now, to determine the angle of descent θ corresponding to each of these heights, employing formula (6);

$$\begin{aligned}
I(V) &= \cdot 874183\,,\\
I(v_1) &= \cdot 810223\,,\\
\therefore\ I(V) - I(v_1) &= \cdot 063960\,,\\
\log\{I(V) - I(v_1)\} &= \bar{2}{\cdot}80591\,,\\
2L\sec\phi &= 10{\cdot}00110\,,\\
\log C &= \cdot 19650\,,\\
\therefore\ \log C\sec^2\phi\{I(V) - I(v_1)\} &= \bar{1}{\cdot}00351\,,\\
C\sec^2\phi\{I(V) - I(v_1)\} &= \cdot 100812\,,\\
\tan\phi &= \cdot 050366\,,\\
\therefore\ \tan\theta_1 &= -\cdot 050446\,,\\
\theta_1 &= 2^\circ\ 53'.
\end{aligned}$$

Since $\tan\theta_1$ is negative, the shot is seen to be descending.

Similarly

$$\theta_2 = 3^\circ\ 8'\,,$$
$$\theta_3 = 3^\circ\ 23'\,,$$
$$\theta_4 = 3^\circ\ 38'.$$

The angle of descent at the end of the range is given by formula (3) or (3a); and from above

$$\begin{aligned}
\frac{A(V) - A(v)}{S(V) - S(v)} &= \cdot 842230\,,\\
I(v) &= \cdot 799086\,,\\
\therefore\ \frac{A(V) - A(v)}{S(V) - S(v)} - I(v) &= \cdot 043144\,,\\
\log\left\{\frac{A(V) - A(v)}{S(V) - S(v)} - L(v)\right\} &= \bar{2}{\cdot}63492\,,\\
2L\sec\phi &= 10{\cdot}00110\,,\\
\log C &= \cdot 19650\,,\\
L\tan\omega &= 8{\cdot}83252\,,\\
\omega &= 3^\circ\ 53'.
\end{aligned}$$

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Ex. 2. In Example 1, find the time of flight to each point.

Denote by t_1, t_2, t_3, t_4 and t the time of flight to each point; then employing formula (4);

$$\begin{aligned} T(V) &= 27{\cdot}8287, \\ T(v_1) &= 25{\cdot}2397, \\ T(V) - T(v_1) &= 2{\cdot}5890, \\ \log\{T(V) - T(v_1)\} &= {\cdot}41313, \\ L\sec\phi &= 10{\cdot}00055, \\ \log C &= {\cdot}19650, \\ \therefore \quad \log t_1 &= {\cdot}61018, \\ \text{and} \quad t_1 &= 4{\cdot}076. \end{aligned}$$

Similarly

$$\begin{aligned} t_2 &= 4{\cdot}217, \\ t_3 &= 4{\cdot}359, \\ t_4 &= 4{\cdot}502, \\ t &= 4{\cdot}647. \end{aligned}$$

Ex. 3. It was recently necessary to fire a 64-pr. converted gun with a charge of 8 lb., giving a muzzle velocity of 1260 f.s., from the Signal Station at Gibraltar, 1270 feet above the level of the sea. The object fired at was 2000 yards from the muzzle of the gun.

Find what was the necessary depression.

Here $d = 6{\cdot}3$, $W = 64{\cdot}5$, $V = 1260$, $s = 6000$, $y = 1270$; to find ϕ.

The coefficient of reduction n may be replaced by unity, since the projectile was similar to that used in Bashforth's experiments; therefore

$$C = \frac{W}{d^2},$$

$$\begin{aligned} \log d &= {\cdot}79934, \\ \log d^3 &= 1{\cdot}59868, \\ \log W &= 1{\cdot}80956, \\ \log C &= {\cdot}21088. \end{aligned}$$

Employing formula (1) or (17)

$$\begin{aligned} \frac{d^2}{W}s &= 3692{\cdot}10, \\ S(V) &= 16935{\cdot}47, \\ S(v) &= 13243{\cdot}37, \\ v &= 893{\cdot}8. \end{aligned}$$

Now, employing formula (23) and finding F (§ 6)

$$\begin{aligned} A(V) &= 6952{\cdot}84, \\ A(v) &= 4037{\cdot}30, \\ A(V) - A(v) &= 2915{\cdot}54, \\ S(V) - S(v) &= 3692{\cdot}10, \\ \log\{A(V) - A(v)\} &= 3{\cdot}46472, \\ \log\{S(V) - S(v)\} &= 3{\cdot}56727, \end{aligned}$$

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$$\therefore \log \frac{A(V)-A(v)}{S(V)-S(v)} = \bar{1}\cdot 89745,$$

$$\frac{A(V)-A(v)}{S(V)-S(v)} = \cdot 78968,$$

$$I(V) = \cdot 84201,$$

$$\therefore I(V) - \frac{A(V)-A(v)}{S(V)-S(v)} = \cdot 05233,$$

$$\log \left\{ I(V) - \frac{A(V)-A(v)}{S(V)-S(v)} \right\} = \bar{2}\cdot 71875,$$

$$\log C = \cdot 21088,$$

$$\therefore \log F = \bar{2}\cdot 92963,$$

$$F = \cdot 085041.$$

The horizontal distance x from the foot of the battery to the object is

$$x = \sqrt{s^2 - y^2},$$

$$= 5864,$$

$$E = \frac{y}{x} = \frac{1270}{5864},$$

$$= \cdot 216576,$$

and E is to be taken negatively, as the object fired at is on a lower level;

$$F - E = - \cdot 131535,$$

$$\log (F-E) = \bar{1}\cdot 11904,$$

$$\log F = \bar{2}\cdot 92963,$$

$$\log 4 = \cdot 60206,$$

$$\log 4F(F-E) = \bar{2}\cdot 65073,$$

$$4F(F-E) = - \cdot 044744,$$

$$1 - 4F(F-E) = 1\cdot 044744,$$

$$\log \{1 - 4F(F-E)\} = \cdot 01901,$$

$$\log \surd\{1 - 4F(F-E)\} = \cdot 009505,$$

$$\surd\{1 - 4F(F-E)\} = 1\cdot 022127,$$

$$1 - \surd\{1 - 4F(F-E)\} = - \cdot 022127,$$

$$\log [1 - \surd\{1 - 4F(F-E)\}] = \bar{2}\cdot 34492,$$

$$\log 2F = \bar{1}\cdot 23066,$$

$$L \tan \phi = 9\cdot 11426,$$

$$\phi = 7^\circ\ 25'.$$

If ψ is the angle of depression of the object, then

$$\tan \psi = E, \quad E = \cdot 2166, \text{ and } \psi = 12^\circ\ 13'.$$

$$\therefore \text{Tangent elevation to be given to the gun} \left\} \begin{array}{l} = \psi - \phi, \\ = 4^\circ\ 48'. \end{array} \right.$$

This example worked out by Niven's method gives $\phi = 7^\circ\ 20'$.

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Ex. 4. An enemy's ship attacking Gibraltar confines itself, at a range of 3000 yards, to firing at the Signal Station, which is known to be 1270 feet high.

The ship is using a 12-inch gun of 45 tons, with a 295 lb. charge giving a muzzle velocity of 1910 f.s.

Find the necessary elevation.

Here $V = 1910$, $W = 714$, $d = 12$, $y = 1270$, $s = 9000$, and taking the coefficient of reduction $n = \cdot 95$, $C = \frac{W}{nd^2}$, and

$$\log d = 1\cdot07918$$
$$\log d^2 = 2\cdot15836$$
$$\log n = \bar{1}\cdot97772$$
$$\log nd^2 = 2\cdot13608$$
$$\log W = 2\cdot85370$$
$$\log C = \cdot71762,$$
$$\frac{s}{C} = 1724\cdot40,$$
$$S(V) = 19850\cdot82,$$
$$\therefore\ S(v) = 18126\cdot42,$$
$$v = 1496.$$

Employing formula (23) and finding F

$$A(V) = 9473\cdot03,$$
$$A(v) = 7965\cdot92,$$
$$\therefore\ A(V) - A(v) = 1507\cdot11,$$
$$S(V) - S(v) = 1724\cdot40,$$
$$\log \{A(V) - A(v)\} = 3\cdot17815,$$
$$\log \{S(V) - S(v)\} = 3\cdot23664,$$
$$\therefore\ \log \frac{A(V) - A(v)}{S(V) - S(v)} = \bar{1}\cdot94151,$$
$$\frac{A(V) - A(v)}{S(V) - S(v)} = \cdot87400,$$
$$I(V) = \cdot882039,$$
$$I(V) - \frac{A(V) - A(v)}{S(V) - S(v)} = \cdot008039,$$
$$\log \left\{ I(V) - \frac{A(V) - A(v)}{S(V) - S(v)} \right\} = \bar{3}\cdot90520,$$
$$\log C = \cdot71762,$$
$$\therefore\ \log F = \bar{2}\cdot62282,$$
$$F = \cdot041957,$$

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The horizontal distance x from the gun to the foot of the perpendicular drawn from the object is

$$\begin{aligned} x &= \sqrt{(s^2 - y^2)}, \\ &= 8910, \\ E = \frac{y}{x} &= \frac{1270}{8910}, \\ &= \cdot 142536; \end{aligned}$$

and E is to be taken positively as the object fired at is on a higher level than the gun;

$$\begin{aligned} F + E &= \cdot 184493, \\ \log (F + E) &= \bar{1} \cdot 26598, \\ \log F &= \bar{2} \cdot 62280, \\ \log 4 &= \cdot 60206, \\ \log 4F(F + E) &= \bar{2} \cdot 49084, \\ 4F(F + E) &= \cdot 030963, \\ 1 - 4F(F + E) &= \cdot 969037, \\ \log \{1 - 4F(F + E)\} &= \bar{1} \cdot 98634, \\ \log \sqrt{\{1 - 4F(F + E)\}} &= \bar{1} \cdot 99317, \\ \sqrt{\{1 - 4F(F + E)\}} &= \cdot 984396, \\ 1 - \sqrt{\{1 - 4F(F + E)\}} &= \cdot 015604, \\ \log [1 - \sqrt{\{1 - 4F(F + E)\}}] &= \bar{2} \cdot 19324, \\ \log 2F &= \bar{2} \cdot 92383, \\ \therefore \quad L \tan \phi &= 9 \cdot 26941, \\ \phi &= 10^\circ\ 32'\ \text{the required elevation}; \\ \text{and } \tan \psi &= E = \cdot 1429, \\ \psi &= 8^\circ\ 7'; \\ \text{therefore the tangent elevation} &= \phi - \psi, \\ &= 10^\circ\ 32' - 8^\circ\ 7', \\ &= 2^\circ\ 25'. \end{aligned}$$

Ex. 5. Supposing, now, the enemy wishes to search the battery with shrapnel fire from the same gun as in the previous Example; find the time of flight and angle of descent or ascent.

Employing formula (4),

$$\begin{aligned} T(V) &= 28 \cdot 2694, \\ T(v) &= 27 \cdot 2463, \\ \therefore \quad T(V) - T(v) &= 1 \cdot 0231, \\ \log \{T(V) - T(v)\} &= \cdot 00992, \\ \log C &= \cdot 71762, \\ L \sec \phi &= 10 \cdot 00738, \\ \therefore \quad \log t &= \cdot 73492, \\ t &= 5 \cdot 43 \text{ seconds}. \end{aligned}$$

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To find the angle of descent, using formula (6),

$$\begin{aligned} I(V) &= \cdot 882039, \\ I(v) &= \cdot 862442, \\ \therefore\ I(V) - I(v) &= \cdot 019597, \\ \log\{I(V) - I(v)\} &= \bar{2}\cdot 29219, \\ \log C &= \cdot 71762, \\ 2L\sec\phi &= 20\cdot 01476, \\ \therefore\ \log C\sec^2\phi\{I(V) - I(v)\} &= \bar{1}\cdot 02457, \\ \text{and}\quad C\sec^2\varphi\{I(V) - I(v)\} &= \cdot 10582, \\ \tan\varphi &= \cdot 18594, \\ \therefore\ \tan\theta &= \cdot 08012, \\ \theta &= 4^\circ\ 35'. \end{aligned}$$

Since θ is positive, the shell must be ascending, and so would strike the battery in an upward direction; the searching effect would consequently be very small.

Ex. 6. Show that there is little difference in the tangent elevation of a gun when firing at an object on the horizontal plane and when firing, at the same range, at an object on a slightly higher or lower level.

Take the 10-inch gun of 18 tons firing at a range of 1000 yards, at an object on a lower level, as an example.

Here $V = 1379$, $W = 406$, $d = 10$, $s = 3000$, to find ϕ, ϕ_1, ϕ_2, and ϕ_3; supposing ϕ_1, ϕ_2, and ϕ_3 to be the quadrant elevation to be given to the gun firing from an elevated battery 100, 200 and 300 feet high.

Supposing the coefficient of reduction n is unity, $C = \frac{W}{d^2}$,

$$\begin{aligned} \log C &= \cdot 60854, \\ \frac{s}{C} &= 738\cdot 90, \\ S(V) &= 17569\cdot 77, \\ \therefore\ S(v) &= 16830\cdot 87, \\ v &= 1242. \end{aligned}$$

To find the elevation when firing at an object on the horizontal plane, we use formula (2);

$$\begin{aligned} A(V) &= 7490\cdot 44, \\ A(v) &= 6864\cdot 46, \\ \therefore\ A(V) - A(v) &= 625\cdot 98, \\ \text{and}\quad S(V) - S(v) &= 738\cdot 90, \\ \log\{A(V) - A(v)\} &= 2\cdot 79656 \\ \log\{S(V) - S(v)\} &= 2\cdot 86859, \end{aligned}$$

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$$\therefore \log \frac{A(V)-A(v)}{S(V)-S(v)} = \bar{1}\cdot 92797,$$

$$\frac{A(V)-A(v)}{S(V)-S(v)} = \cdot 847170,$$

$$I(V) = \cdot 853781,$$

$$\therefore I(V)-\frac{A(V)-A(v)}{S(V)-S(v)} = \cdot 006611,$$

$$\log\left\{I(V)-\frac{A(V)-A(v)}{S(V)-S(v)}\right\} = \bar{3}\cdot 82027,$$

$$\log C = \cdot 60854,$$

$$\log 2 = \cdot 30103,$$

$$\therefore L\sin 2\phi = 8\cdot 72984,$$

$$2\phi = 3^\circ\ 5',$$

$$\phi = 1^\circ\ 32'\cdot 5,$$

the elevation required by the gun on the level.

Again, to find the elevation required for a battery 100 feet high, using formula (23),

$$\log\left\{I(V)-\frac{A(V)-A(v)}{S(V)-S(v)}\right\} = \bar{3}\cdot 82027,$$

$$\log C = \cdot 60854,$$

$$\therefore \log F = \bar{2}\cdot 42881,$$

$$\text{and} \quad F = \cdot 026841,$$

$$E = \frac{y}{x} = \frac{y}{\sqrt{s^2-y^2}},$$

$$= \frac{100}{2998} = \cdot 033355;$$

and E has to be taken negatively, as we are firing downwards.

$$\therefore F-E = -\cdot 006514,$$

$$\log(F-E) = \bar{3}\cdot 81385,$$

$$\log F = \bar{2}\cdot 42881,$$

$$\log 4 = \cdot 60206,$$

$$\log 4F(F-E) = \bar{4}\cdot 84472.$$

$$\therefore 4F(F-E) = -\cdot 00069939,$$

$$1-4F(F-E) = 1\cdot 00069939,$$

$$\log\{1-4F(F-E)\} = \cdot 00030,$$

$$\log\sqrt{\{1-4F(F-E)\}} = \cdot 00015,$$

$$\sqrt{1-4F(F-E)} = 1\cdot 0003496,$$

$$1-\sqrt{\{1-4F(F-E)\}} = -\cdot 0003496,$$

$$\log[1-\sqrt{\{1-4F(F-E)\}}] = \bar{4}\cdot 54357,$$

$$\log 2F = \bar{2}\cdot 72984.$$

$$\therefore L\tan\phi_1 = -7\cdot 81373,$$

$$\phi_1 = 22'\cdot 4,$$

an angle of depression, since $\tan\phi_1$ is a negative quantity.

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If ψ_1 be the angle of depression of the line of sight, then

$$E = \tan \psi_1,$$
$$\text{and} \quad \tan \psi_1 = \cdot 033355,$$
$$\psi_1 = 1^\circ\ 54'\cdot 5.$$

Therefore the tangent elevation for the high site is

$$\psi_1 - \phi_1 = 1^\circ\ 32'\cdot 1.$$

If the same calculation be made, taking the height of the battery as 200 feet,

$$\psi_2 = 3^\circ\ 49'\cdot 4,$$
$$\phi_2 = 2^\circ\ 17'\cdot 2,$$
$$\psi_2 - \phi_2 = 1^\circ\ 32'\cdot 2.$$

For a battery 300 feet high,

$$\psi_3 = 5^\circ\ 45'\cdot 4,$$
$$\phi_3 = 4^\circ\ 12'\cdot 2,$$
$$\therefore \quad \psi_3 - \phi_3 = 1^\circ\ 33'\cdot 2.$$

So that at a range of 1000 yards, which is a short range, the difference in the tangent elevations begins to be appreciable when the battery is above 300 feet high. For longer ranges the difference would not, of course, be so much.

By similar calculations it can be shown that, if the gun is firing at an object on a higher level, the tangent elevation is practically the same.

Ex. 7. An escarp had to be breached at the Siege of Strasburg by a gun, equivalent to an 8-inch howitzer of 70 cwt., on the same level. From information received from a spy, the ditch was known to be about 50 feet wide; in consequence of which the necessary angle of descent was calculated to be 14°. The howitzer was using common shell and delay-action fuze, and the Engineers required that the striking velocity was not to fall short of 600 f.s.

Find the least requisite distance of the howitzer from the escarp, the requisite charge of powder and angle of elevation.

Here $W = 180$, $d = 8$, $v = 600$, $\omega = 14^\circ$; to find s, V and ϕ;

$$C = \frac{W}{d^3},$$
$$\log C = \cdot 44909.$$

We first proceed to find V, the muzzle velocity; using formula (3)*;

$$L \sin 2\omega = 9\cdot 67161,$$
$$\therefore \quad \log \frac{\sin 2\omega}{2C} = \bar{2}\cdot 92149,$$
$$\frac{\sin 2\omega}{2C} = \cdot 08346,$$
$$I(v) = \cdot 32325,$$
$$\frac{A(V) - A(v)}{S(V) - S(v)} = I(v_0) = \cdot 40671,$$
$$\therefore \quad v_0 = 637.$$

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Now, supposing that the time of flight from the muzzle to the vertex is half the whole time of flight, we have, employing formula (4),

$$T(V) = 2T(v_0) - T(v)$$

For, whole time of flight,

$$t = C \sec \phi \{ T(V) - T(v) \},$$

Time of flight to vertex,

$$\tfrac{1}{2} t = C \sec \phi \{ T(V) - T(v)_0 \},$$

Equating these equations we obtain,

$$\begin{aligned} T(V) &= 2T(v_0) - T(v), \\ T(v_0) &= 15{\cdot}3747, \\ 2T(v_0) &= 30{\cdot}7494, \\ T(v) &= 13{\cdot}7638, \\ \therefore \quad T(V) &= 16{\cdot}9856, \\ \text{and} \quad V &= 679. \end{aligned}$$

The charge must therefore be such as to give this velocity to the projectile, and from the range table issued with the howitzer, this would be about 6 lbs. R.L.G.^{2} powder.

The range s is now obtained directly from formula (1);

$$\begin{aligned} S(V) &= 8756{\cdot}34, \\ S(v) &= 6691{\cdot}06, \\ S(V) - S(v) &= 2065{\cdot}28, \\ \log \{S(V) - S(v)\} &= 3{\cdot}31498, \\ \log C &= {\cdot}44909, \\ \therefore \quad \log s &= 3{\cdot}76407, \\ s &= 5809, \end{aligned}$$

a range of 1936 yards.

To obtain a greater striking velocity than 600 f.s., the range of the battery would have to be increased.

The angle of elevation is found by equation (2);

$$\begin{aligned} I(V) &= {\cdot}48678, \\ \frac{A(V) - A(v)}{S(V) - S(v)} &= {\cdot}40671, \\ \therefore \quad I(V) - \frac{A(V) - A(v)}{S(V) - S(v)} &= {\cdot}08007, \\ \log \left\{ I(V) - \frac{A(V) - A(v)}{S(V) - S(v)} \right\} &= \bar{2}{\cdot}90347, \\ \log 2 &= {\cdot}30103, \\ \log C &= {\cdot}44909, \\ \therefore \quad L \sin 2\phi &= 9{\cdot}65359, \\ 2\phi &= 26^\circ\ 46', \\ \phi &= 13^\circ\ 23', \end{aligned}$$

the requisite elevation.

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In order to find what error has crept in by taking formula (3)* at starting, we will now find the angle of descent from formula (3) ;

$$\frac{A(V)-A(v)}{S(V)-S(v)} = \cdot 40671,$$

$$I(v) = \cdot 32325,$$

$$\frac{A(V)-A(v)}{S(V)-S(v)} - I(v) = \cdot 08346,$$

$$\log\left\{\frac{A(V)-A(v)}{S(V)-S(v)} - I(v)\right\} = \bar{2}\cdot 92148,$$

$$\log C = \cdot 44909,$$

$$2L \sec\phi = 10\cdot 02392,$$

$$\therefore \quad \tan\omega = 9\cdot 39449,$$

$$\omega = 13^\circ\ 56';$$

an error of only 4′.

Ex. 8. The 6-inch B.L. gun required according to the range-table an elevation of 1° 51′ and a muzzle velocity of 1850 f.s., to hit an object at 2000 yards range. It was, however, found that the actual range obtained with this elevation was only 1800 yards, and on investigation the powder was found to have deteriorated from damp. What extra elevation had to be given to compensate for the deterioration of the powder, supposing the weight of the projectile is 100 lbs. and the jump 3′ ?

Here $W = 100$, $d = 6$, and take $n = \cdot 92$, $s = 5400$, $\phi = 1^\circ\ 51' +$ jump $= 1^\circ\ 54'$.

$$\log C = \cdot 47991.$$

From formula (2) we see that in this example $\frac{\sin 2\phi}{2C}$ is a constant quantity

$$L \sin 2\phi = 8\cdot 82134,$$

$$\log 2C = \cdot 78094,$$

$$\log \frac{\sin 2\phi}{2C} = \bar{2}\cdot 04040,$$

$$\frac{\sin 2\phi}{2C} = \cdot 010975,$$

$$\therefore \quad I(V) - \frac{A(V)-A(v)}{S(V)-S(v)} = \cdot 010975.$$

The expression on the left increases as V decreases. So that if we assume a value for V and calculate this quantity, which we will suppose is greater than the given value on the right, we shall have to increase the value of V.

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Assume

$$V = 1800,$$
$$S(V) = 19421{\cdot}26,$$
$$\frac{s}{C} = 1788{\cdot}48,$$
$$S(v) = 17632{\cdot}78,$$
$$v = 1391{\cdot}8.$$
$$A(V) = 9095{\cdot}07,$$
$$A(v) = 7544{\cdot}42,$$
$$A(V) - A(v) = 1550{\cdot}65,$$
$$S(V) - S(v) = 1788{\cdot}48,$$
$$\log\{A(V) - A(v)\} = 3{\cdot}19051,$$
$$\log\{S(V) - S(v)\} = 3{\cdot}25248,$$
$$\log\frac{A(V) - A(v)}{S(V) - S(v)} = \bar{1}{\cdot}93803,$$
$$\frac{A(V) - A(v)}{S(V) - S(v)} = {\cdot}867022,$$
$$I(V) = {\cdot}878015,$$
$$\therefore\ I(V) - \frac{A(V) - A(v)}{S(V) - S(v)} = {\cdot}010993,$$

which is very nearly correct.

If we assume $V = 1801$, and work in a similar manner, we find

$$I(V) - \frac{A(V) - A(v)}{S(V) - S(v)} = {\cdot}010949,$$

so that the muzzle velocity is about 1800·5 f.s.; suppose it is 1800 f.s.

We now have to find the necessary elevation, with this velocity, to hit an object at 2000 yards;

$$\frac{s}{C} = 1987{\cdot}20,$$
$$S(V) = 19421{\cdot}26,$$
$$\therefore\ S(v) = 17434{\cdot}06,$$
$$v = 1351{\cdot}9,$$
$$A(V) = 9095{\cdot}07,$$
$$A(v) = 7374{\cdot}07,$$
$$\therefore\ A(V) - A(v) = 1721{\cdot}00,$$
$$S(V) - S(v) = 1987{\cdot}20,$$
$$\log\{A(V) - A(v)\} = 3{\cdot}23578,$$
$$\log\{S(V) - S(v)\} = 3{\cdot}29824,$$
$$\therefore\ \log\frac{A(V) - A(v)}{S(V) - S(v)} = \bar{1}{\cdot}93754,$$
$$\frac{A(V) - A(v)}{S(V) - S(v)} = {\cdot}866044,$$
$$I(V) = {\cdot}878015,$$

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$$\therefore\ I(V) - \frac{A(V) - A(v)}{S(V) - S(v)} = \quad \cdot 011971,$$

$$\log\left\{I(V) - \frac{A(V) - A(v)}{S(V) - S(v)}\right\} = \quad \bar{2}\cdot 07813,$$

$$\log C = \quad \cdot 47991,$$

$$\log 2 = \quad \cdot 30103,$$

$$\therefore\ L \sin 2\phi = \quad 8\cdot 85907,$$

$$2\phi = 4^\circ\ 9'.$$

$$\phi = 2^\circ\ 4'\cdot 5.$$

Therefore elevation to be given to the gun

$$= \phi - \text{jump},$$

$$= 2^\circ\ 1'\cdot 5.$$

Extra elevation required

$$= 2^\circ\ 1'\cdot 5 - 1^\circ\ 51'.$$

$$= 10'\cdot 5.$$

Ex. 9. A Committee was recently appointed to recommend a new rifle which should have a velocity of 800 f.s. at 1000 yards range with a maximum height of the trajectory of 32 feet.

Determine the proportions of weight of bullet to calibre to fulfil these conditions.

Here $v = 800$, $X = 3000$, $y_0 = 32$; to find C, and thence d or W.

Assume the muzzle velocity to be 1890 f.s., then by a calculation similar to that worked out below, we find that the height of the vertex is 32·47 feet, and for a muzzle velocity of 1990 f.s. the height is 31·55 feet. The true velocity must therefore lie beween these two.

Therefore, assuming the initial velocity to be 1940 f.s., we proceed to work out the height of the vertex, and using formula (1) to find the value of C when $V = 1940$, $v = 800$, $X = 3000$;

$$S(V) = 19964\cdot 85,$$

$$S(v) = 11498\cdot 56,$$

$$\frac{X}{C} = \quad 8466\cdot 29,$$

$$\log\frac{X}{C} = \quad 3\cdot 92769,$$

$$\log X = \quad 3\cdot 47712,$$

$$\log C = \quad \bar{1}\cdot 54943,$$

Now $$A(V) = \quad 9573\cdot 65,$$

$$A(v) = \quad 2838\cdot 91,$$

$$\therefore\ A(V) - A(v) = \quad 6734\cdot 74,$$

$$S(V) - S(v) = \quad 8466\cdot 29,$$

$$\log\{A(V) - A(v)\} = \quad 3\cdot 82832,$$

$$\log\{S(V) - S(v)\} = \quad 3\cdot 92769,$$

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$$\therefore \log \frac{A(V)-A(v)}{S(V)-S(v)} = \bar{1}\cdot 90063,$$

$$\frac{A(V)-A(v)}{S(V)-S(v)} = \cdot 795481,$$

$$I(V) = \cdot 883029,$$

$$I(V) - \frac{A(V)-A(v)}{S(V)-S(v)} = \cdot 087548,$$

$$\log\left\{I(V) - \frac{A(V)-A(v)}{S(V)-S(v)}\right\} = \bar{2}\cdot 94225,$$

$$\log C = \bar{1}\cdot 54943,$$

$$\log 2 = \cdot 30103,$$

$$L\sin 2\phi = 8\cdot 79271,$$

$$2\phi = 3^\circ\ 33'\cdot 4,$$

$$\phi = 1^\circ\ 46'\cdot 7.$$

To find the distance x_0 from the point of discharge to the vertex.

$$I(v_0) = \frac{A(V)-A(v)}{S(V)-S(v)} = \cdot 795481,$$

$$v_0 = 1022\cdot 5.$$

Now using formula (1) or (17),

$$S(V) = 19964\cdot 85,$$

$$S(v_0) = 15120\cdot 54,$$

$$S(V) - S(v_0) = 4844\cdot 31,$$

$$\log\{S(V) - S(v_0)\} = 3\cdot 68523,$$

$$\log C = \bar{1}\cdot 54943,$$

$$\log x_0 = 3\cdot 23466,$$

$$x_0 = 1716.$$

We can now find the height of the vertex. Using formula (7);

$$A(V) = 9573\cdot 65,$$

$$A(v_0) = 5465\cdot 90,$$

$$\therefore A(V) - A(v_0) = 4107\cdot 75,$$

$$\log\{A(V) - A(v_0)\} = 3\cdot 61360,$$

$$\log\{S(V) - S(v_0)\} = 3\cdot 68523,$$

$$\therefore \log \frac{A(V)-A(v_0)}{S(V)-S(v_0)} = \bar{1}\cdot 92837,$$

$$\frac{A(V)-A(v_0)}{S(V)-S(v_0)} = \cdot 847950,$$

$$I(V) = \cdot 883029,$$

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$$\therefore \quad I(V) - \frac{A(V) - A(v_0)}{S(V) - S(v_0)} = \cdot 035079,$$

$$\log \left\{ I(V) - \frac{A(V) - A(v_0)}{S(V) - S(v_0)} \right\} = \bar{2}\cdot 54505,$$

$$2L \sec \phi = 10\cdot 00042,$$

$$\log C = \bar{1}\cdot 54943,$$

$$\log C \sec^2\phi \left\{ I(V) - \frac{A(V) - A(v_0)}{S(V) - S(v_0)} \right\} = \bar{2}\cdot 09490,$$

$$C \sec^2\phi \left\{ I(V) - \frac{A(V) - A(v_0)}{S(V) - S(v_0)} \right\} = \cdot 012442,$$

$$\tan \phi = \cdot 031048,$$

$$\therefore \quad \frac{y}{x_0} = \cdot 018606,$$

$$\log \frac{y}{x_0} = \bar{2}\cdot 26965,$$

$$\log x_0 = 3\cdot 23466,$$

$$\therefore \log y = 1\cdot 50431,$$

$$y = 31\cdot 938.$$

and this is practically 32 feet.

Now suppose the bore of the rifle is settled to be 0·38 inches, then $C = \frac{W}{d^3}$, and $d = 0\cdot 38$;

$$\log d = \bar{1}\cdot 57978,$$

$$\log d^2 = \bar{1}\cdot 15956,$$

$$\log C = \bar{1}\cdot 54943,$$

$$\log W = \bar{2}\cdot 70899,$$

$$W = \cdot 05117,$$

so that the weight of the bullet in grains is $\cdot 05117 \times 7000 = 358$.

So that if the diameter of the bullet is 0·38, and its weight 358 grains, its initial velocity must be 1940 f.s.

But for a bore of 0·32, the weight of the bullet must be 254 grains, with an initial velocity of 1940 f.s. to secure the above conditions.

Ex. 10. Fire is being carried out against the side of an iron-clad 10 feet above the water-line, by a 12·5-inch gun of 38 tons, with a muzzle velocity of 1575 f.s., and a 809 lb. 6 oz. shot, from a battery 80 feet high above the sea level and 1500 yards from the ship. What error made in finding the range will admit of the projectile striking the side?

Here $V = 1575$, $d = 12\cdot 5$, $W = 809\cdot 375$, $s = 4500$;

$$\log d = 1\cdot 09691,$$

$$\log d^2 = 2\cdot 19382,$$

$$\log W = 2\cdot 90815,$$

$$\log C = \cdot 71433.$$

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First consider that the point aimed at is on the water-line of the ship.

We have to find the elevation so as just to hit the top of the target, so that here

$$y = 80 - 10 = 70 .$$

The horizontal distance from the object to the foot of the battery is

$$\begin{aligned} x &= \sqrt{s^2 - y^2} = \sqrt{(s-y)(s+y)}, \\ &= \sqrt{4430 \times 4570}, \\ &= 4499, \\ &= 4500 \text{ practically} . \end{aligned}$$

Using (1) or (17),

$$\begin{aligned} \frac{s}{C} &= 868{\cdot}72, \\ S(V) &= 18477{\cdot}47, \\ S(v) &= 17608{\cdot}75, \\ v &= 1387 . \end{aligned}$$

Now using formula (23),

$$\begin{aligned} A(V) &= 8271{\cdot}50, \\ A(v) &= 7524{\cdot}23, \\ \therefore\ A(V) - A(v) &= 747{\cdot}27, \\ S(V) - S(v) &= 868{\cdot}72, \\ \log\{A(V) - A(v)\} &= 2{\cdot}87348, \\ \log\{S(V) - S(v)\} &= 2{\cdot}93888, \\ \therefore\ \log \frac{A(V) - A(v)}{S(V) - S(v)} &= \bar{1}{\cdot}93460, \\ \frac{A(V) - A(v)}{S(V) - S(v)} &= {\cdot}860201, \\ I(V) &= {\cdot}867274, \\ \therefore\ I(V) - \frac{A(V) - A(v)}{S(V) - S(v)} &= {\cdot}007073, \\ \log\left\{I(V) - \frac{A(V) - A(v)}{S(V) - S(v)}\right\} &= \bar{3}{\cdot}84960, \\ \log C &= {\cdot}71433, \\ \log F &= \bar{2}{\cdot}56393, \\ F &= {\cdot}036638; \end{aligned}$$

$$\begin{aligned} E = \frac{y}{x} &= \frac{70}{4500} \\ &= {\cdot}013333 . \end{aligned}$$

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Here E is to be taken negatively.

$$\begin{aligned}
\therefore \quad F - E &= \cdot 023305, \\
\log (F - E) &= \bar{2}\cdot 36745, \\
\log F &= \bar{2}\cdot 56393, \\
\log 4 &= \cdot 60206, \\
\log 4F(F - E) &= \bar{3}\cdot 53344, \\
4F(F - E) &= \cdot 0034154, \\
1 - 4F(F - E) &= \cdot 9965846, \\
\log \{1 - 4F(F - E)\} &= \bar{1}\cdot 99851, \\
\log \sqrt{\{1 - 4F(F - E)\}} &= \bar{1}\cdot 99926, \\
\sqrt{\{1 - 4F(F - E)\}} &= \cdot 998291, \\
1 - \sqrt{\{1 - 4F(F - E)\}} &= \cdot 001709, \\
\log [\{1 - \sqrt{1 - 4F(F - E)}\}] &= \bar{3}\cdot 23274, \\
\log 2F &= \bar{2}\cdot 86496, \\
L \tan \phi &= 8\cdot 36778, \\
\phi &= 1^\circ\ 20'; \\
\text{and } \tan \psi = E &= \cdot 01333, \\
\psi &= 46', \text{ therefore} \\
\text{the tangent elevation} = \phi + \psi &= 1^\circ\ 20' + 46'. \\
&= 2^\circ\ 6'.
\end{aligned}$$

We now find the angle of descent at the top of the target, using formula (6);

$$\begin{aligned}
I(V) &= \cdot 867274, \\
I(v) &= \cdot 854447, \\
\therefore \quad I(V) - I(v) &= \cdot 012827, \\
\log \{I(V) - I(v)\} &= \bar{2}\cdot 10813, \\
2L \sec \phi &= 10\cdot 00024, \\
\log C &= \cdot 71433, \\
\therefore \quad \log C \sec^2 \phi \{I(V) - I(v)\} &= 2\cdot 82270, \\
C \sec^2 \phi \{I(V) - I(v)\} &= \cdot 066481, \\
\tan \phi &= \cdot 023275, \\
\tan \theta &= -\cdot 043206, \\
\theta &= 2^\circ\ 29',
\end{aligned}$$

and the projectile is moving downwards, since tan θ is negative.

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Now, we ought to find how far along the line of sight through the foot of the target the shot would intersect. But as the angle the line of sight makes with the horizontal is so small, we can find this distance approximately, considering that the shot travels in a straight line from the top of the target. It will be found by using the more rigorous method of Niven that this is very nearly the proper distance.

So that if x_1 is the distance from the foot of the target to where the trajectory crosses the line of sight, and putting

$$\begin{aligned}\tan \theta_1 &= \frac{\text{height of battery}}{\text{horizontal range}} \\ &= \frac{80}{4500} \\ &= \cdot 01777, \\ \theta_1 &= 1^\circ\ 1', \\ x_1 &= 10 \cot (\theta - \theta_1) \\ &= 10 \cot 1^\circ\ 28', \\ &= 10 \times 39 \cdot 143, \\ &= 391 \cdot 43 \text{ feet.}\end{aligned}$$

so that the range could be over-estimated by this amount.

Now suppose we wanted to fire at the centre of the target, then if x' is the distance from the centre of the target to where the trajectory crosses the line of sight and putting

$$\begin{aligned}\frac{y}{x'} &= \tan \theta' = \cdot 015555, \\ \therefore \quad \theta' &= 53', \\ \frac{x'}{5} &= \cot (\theta - \theta') \\ &= \cot 1^\circ\ 36', \\ \therefore \quad x' &= 5 \times 35 \cdot 80 \\ &= 179 \text{ feet.}\end{aligned}$$

So that the range may be over-estimated by this distance—about 60 yards—and the target would still be hit.

We now have to find how much the range may be under-estimated. In this case F is practically the same, so finding ϕ, and then θ, the angle of descent,

$$\begin{aligned}E = \frac{y}{x} &= \frac{80}{4500}, \\ &= \cdot 017777,\end{aligned}$$

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and E is negative; so using formula (23),

$$F = \cdot 036638,$$
$$E = \cdot 017777,$$
$$\therefore \quad F - E = \cdot 018861,$$
$$\log (F - E) = \bar{2}\cdot 27556,$$
$$\log F = \overline{2\cdot 56393},$$
$$\log 4 = \cdot 60206,$$
$$\therefore \quad \log 4F(F - E) = \bar{3}\cdot 44155,$$
$$4F(F - E) = \cdot 0027641,$$
$$1 - 4F(F - E) = \cdot 9972359,$$
$$\log \{1 - F(F - E)\} = \bar{1}\cdot 99880,$$
$$\log \surd\{1 - 4F(F - E)\} = \bar{1}\cdot 99940,$$
$$\surd\{1 - 4F(F - E)\} = \cdot 998617,$$
$$1 - \surd\{1 - 4F(F - E)\} = \cdot 001383,$$
$$\log [1 - \surd\{1 - 4F(F - E)\}] = \bar{3}\cdot 14082,$$
$$\log 2F = \bar{2}\cdot 86496,$$
$$\therefore \quad L \tan \phi = 8\cdot 27586,$$
$$\phi = 1^\circ\ 5',$$
$$\tan \psi = \cdot 01777,$$
$$\psi = 1^\circ\ 1';$$
$$\therefore \text{ tangent elevation } = 2^\circ\ 6', \text{ as before.}$$

We now find the angle of descent at the bottom of the target;

$$\log \{I(V) - I(v)\} = \bar{2}\cdot 10813,$$
$$2L \sec \phi = 10\cdot 00016,$$
$$\log C = \cdot 71433,$$
$$\therefore \quad \log C \sec^2\phi \{I(V) - I(v)\} = \bar{2}\cdot 82262,$$
$$C \sec^2\phi \{I(V) - I(v)\} = \cdot 066469,$$
$$\tan \phi = \cdot 018910,$$
$$\therefore \quad \tan \theta = - \cdot 047559,$$
$$\theta = 2^\circ\ 43', \text{ downwards.}$$

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So that if x'' is the distance from the centre of the target to where the lower trajectory crosses the line of sight, through the water-line of the target, and recollecting that $\frac{y}{x} = \tan \theta'$

$$\frac{x''}{5} = \cot(\theta - \theta'),$$
$$= \cot 1^\circ\ 50',$$
$$\therefore\ x'' = 5 \times 31{\cdot}24,$$
$$= 156{\cdot}2;$$

or the range may be under-estimated 52 yards when firing at the centre of the ship's side. If the water-line is being fired at the range ought not to be under-estimated in order to make a direct hit.

Ex. 11. A ship is attacking a fort, 1400 feet high, situated on a cliff which is practically vertical. The distance from the foot of the cliff to the ship is 1400 yards; and the vessel is using a 5-inch B.L. gun, which fires a projectile of 50 lbs. with a muzzle velocity of 1780 f.s. The diameter of the projectile is 4·96 inches. Find the necessary tangent elevation.

Here $V = 1780$, $W = 50$, $d = 4{\cdot}96$, taking $n = {\cdot}92$, $x = 4200$, $y = 1400$, to find ϕ;

$$\log C = \ {\cdot}34422.$$

We must first find s, the range;

$$s = \sqrt{y^2 + x^2} = 4427.$$

If $\bar{\phi}$ is the mean angle of elevation, then

$$\tan \bar{\phi} = \frac{y}{x},$$
$$= \frac{1400}{4200},$$
$$= {\cdot}333333,$$
$$\therefore\ \bar{\phi} = 18^\circ\ 26'.$$

Here the angle of elevation is too great to use the ordinary method, so we have to use Mayevski's equations and make corrections for the elevation.

These corrections are;

$$U = a\, V \cos \phi,$$
$$u = a\, v \cos \theta,$$

where $a = \sec \bar{\phi}$.

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We first have to approximate to the angle of elevation. Looking for the elevation for a range of 1479 yards in the range table for a 5-inch gun, we find that the tangent elevation given is 1° 32′, but we know that in firing at a high battery more elevation is required, so we shall assume this to be 1° 40′.

Now, quadrant elevation = tangent elevation,
+ angle of elevation of object, or mean angle of elevation.

$$\therefore \quad \phi = 1^\circ\ 40' + \overline{\phi}$$
$$= 20^\circ\ 6'.$$

Now

$$\log V = 3{\cdot}25042,$$
$$L \cos \phi = 9{\cdot}97271,$$
$$L \sec \overline{\phi} = 10{\cdot}02287,$$
$$\log U = 3{\cdot}24600,$$
$$U = 1761{\cdot}9.$$

To find u, using (1),

$$\frac{s}{C} = 2003{\cdot}96$$
$$S(U) = 19267{\cdot}91,$$
$$\therefore \quad S(u) = 17263{\cdot}95,$$
$$u = 1319{\cdot}4.$$

To find the necessary elevation, using (15);

$$A(U) = 8960{\cdot}59,$$
$$A(u) = 7230{\cdot}22,$$
$$\therefore \quad A(U) - A(u) = 1730{\cdot}37,$$
$$S(U) - S(u) = 2003{\cdot}96,$$
$$\log \{A(U) - A(u)\} = 3{\cdot}23814,$$
$$\log \{S(U) - S(u)\} = 3{\cdot}30189,$$
$$\therefore \quad \log \frac{A(U) - A(u)}{S(U) - S(u)} = \overline{1}{\cdot}93625,$$
$$\frac{A(U) - A(u)}{S(U) - S(u)} = {\cdot}863475,$$
$$I(U) = {\cdot}876458,$$

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$$\therefore \quad I(U) - \frac{A(U) - A(u)}{S(U) - S(u)} = \quad \cdot 012983,$$

$$\log \left\{ I(U) - \frac{A(U) - A(u)}{S(U) - S(u)} \right\} = \quad \bar{2} \cdot 11338,$$

$$\log C = \quad \cdot 34422,$$

$$L \sec \bar{\phi} = \quad 10 \cdot 02287,$$

$$\therefore \quad \log C \sec \bar{\phi} \left\{ I(U) - \frac{A(U) - A(u)}{S(U) - S(u)} \right\} = \bar{2} \cdot 48047,$$

and $$C \sec \bar{\phi} \left\{ I(U) - \frac{A(U) - A(u)}{S(U) - S(u)} \right\} = \cdot 030232,$$

$$\frac{y}{x} = \tan \bar{\phi} = \cdot 333333,$$

$$\therefore \quad \tan \phi = \quad \cdot 363565,$$

$$\phi = 19^\circ \ 59'.$$

$$\tan \psi = E = \cdot 3333,$$

$$\psi = 18^\circ \ 26',$$

$$\therefore \quad \text{Tangent elevation} = 1^\circ \ 33'.$$

(To be continued).

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LAYING AT AN INVISIBLE OBJECT.

BY

LIEUT. E. T. DIXON, R.H.A.

I WAS very much struck by an incident related by a distinguished general officer the other day, in my presence. He was saying how favourably our artillery compared with that of any other nation, except in one respect, namely, in the practical science of hitting an enemy. He mentioned as an instance of this that the other day he had been inspecting a battery, and had ordered them to come into action against a village from behind the brow of a hill, so as to remain out of sight of the enemy. Only one sub-division out of six laid out its pickets even approximately correctly. This is a point on which all our men are instructed theoretically, and occasionally practically also; but there is no recognised system laid down in the drill book, and I find that at standing gun drill, if I order pickets to be laid out, and show the men how to do it, they do it all right at the time; but they look upon it as merely an amiable fad of mine—not as real drill. Consequently next week they have forgotten how they did it; and moreover, no doubt, think it amuses me to explain it to them again.

The remedy would be to have a regular drill laid down, and I propose something like this should be inserted in the "Manual of Field Artillery Exercises:"—

"Immediately on the word 'action' if the target (in possession of the enemy), is hidden by the brow of a hill, or similar obstacle Nos. 1, 3, and 12 of each detachment gallop to the front under the charge of an officer" (probably the Major himself, as he would go on, or would already have gone on, to inspect the enemy's position), "No. 3 halts as soon as the target becomes visible. No. 1 as a rule dismounts here, and advances on foot so as to be less conspicuous. No. 12 is horse-holder. No. 1 carries a picket or other mark on which his gun is to be laid, and advances as far to the front as he can, remembering that his picket when planted has to be visible from the level of his gun-sights. No. 3's duty consists in keeping himself constantly in line with the target and No. 1, by moving to the right or left. He might sometimes do this best by remaining mounted, as by so doing he could get a longer base from himself to the No. 1. Or he may dismount, holding his drawn sword vertically downwards as a mark for No. 1, taking care when dressing himself on No. 1, to get his eye vertically over the sword blade. No. 1, when he reaches his first position looks at the muzzle of his gun and moves to the right or left according as the muzzle is to the right or left of No. 3's sword blade. No 3 follows his motion continuously as well as he can, and when No. 1 halts, and holds up his picket, No. 3 dresses his sword accurately in line with it and the target, and, when satisfied, holds up his hand as a signal to No. 1, who then proceeds as before, or if the

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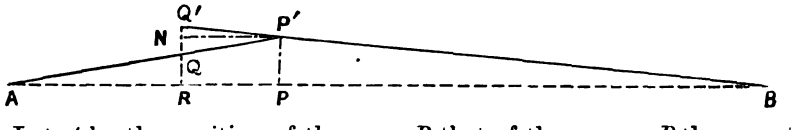
dressing is correct plants his picket and returns to No. 3. The Major, or officer in charge then checks the dressing if necessary, and the numbers return to the battery. Here each No. 1 makes a mark on the ground, or drives in a picket, where the right gun wheel stands, so that he may run the gun up every time to the same spot before laying on the picket.

"The first round the elevation is given by quadrant, but after giving it the No. 1 puts up his tangent-scale until the sights are laid exactly on the picket. For subsequent rounds he lays with his tangent scale alone, on the picket, putting it up to the same elevation, or giving more or less elevation on it according as the first round fell short or over, as if he were really firing on the picket."

A paragraph like this would be an immense assistance to subalterns. It is unfortunately true that men learn drill much more easily than common sense.

The system of making a mark on the ground by the gun wheel is very superior to the old dodge with two pickets. The only use of the second picket was to ensure the gun being run up into the same line every time, and obviously a gun can be run up to a mark on the ground much more accurately and quickly than into a line marked by two distinct pickets. The use of the two pickets is an instance of what the general officer who suggested these ideas to me, called "fluf."

The probable error in laying out pickets on this system may easily be calculated.



Let A be the position of the gun, B that of the enemy, P the correct position of the picket, P' where it is actually placed. (PP' is supposed perpendicular to AB).

First, suppose No. 1 makes the error, *i.e.*, if Q' be the position of No. 3, $Q'P'B$ is a straight line. Draw $Q'QR$ perpendicular to AB cutting AP' in Q and AB in R. Draw PN perpendicular to QR. Then:—

$$QQ' = QN + NQ' = P'N(\tan NP'Q + \tan NP'Q')$$
$$= P'N(\tan A + \tan B).$$

$$\text{But } \tan A = \frac{PP'}{AP}; \quad \tan B = \frac{PP'}{BP}$$

$$\therefore QQ' = P'N \cdot PP'\left(\frac{1}{AP} + \frac{1}{BP}\right) = P'N \; PP' \frac{AB}{AP.PB},$$

and
$$\frac{QQ'}{P'N} = \frac{PP'.AB}{AP.PB} = \frac{AB}{PB}\tan A = \frac{AB}{AP'}\tan B.$$

Ultimately $\frac{QQ'}{P'N}$ is the angular error made by No. 1, and tan A is

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the angular error resulting in the direction of the picket on which the gun is laid. Hence—

$$\text{Angular error due to No. 1's error} = \frac{P'B}{AB} \times \text{that error.}$$

Similarly we may show that—

$$\text{Angular error due to No. 3's error} = \frac{Q'B}{AB} \times \text{that error.}$$

Hence, assuming that the probable error of the men is equal, we get—

$$\text{Whole error} = \frac{P'B \pm Q'B}{AB} \times \text{probable error of one man.*}$$

Since $P'B$ and $Q'B$ are very nearly equal, $Q'P'$ being very small (as a rule) compared to $Q'B$ we have—

$$\text{Whole error} = \text{zero, or } 2\,\frac{PB}{AB} \times \text{by probable error of one man.}$$

So we may say,—

$$\text{Probable error in laying the gun} = \frac{PB}{AB} \text{ of probable error of a man}$$

dressing a picket. This shows the advantage of sending the No. 1 as far to the front as possible.

I have been estimating errors by angles, and by this method, you see, the length of PQ is immaterial. But this would only be true if the men could be relied upon to dress the pickets conscientiously, and not to stop till they had obtained the greatest possible accuracy. In practice the No. 1 is very apt to say to himself "No. 3's sword is very near the right line; I will move my picket one more yard to the left, and leave it." If this is done, incalculable errors will result, particularly if PQ is small. For this reason PQ should be made as large as possible.

No. 1 may however form a rough idea of how much further he will have to go, from observing how far No. 3 is out of the line from himself to the muzzle of the gun.

For, as above,—

$$QQ' = \frac{P'N \,.\, PP' \,.\, AB}{AP \,.\, PB},$$

$$\frac{PP'}{QQ'} = \frac{\frac{PB}{P'N}}{\frac{AB}{AP}} = \frac{\frac{P'B}{P'Q'}}{\frac{AB}{AP}}.$$

For instance, he judges the enemy to be 2200 yds. off, and the battery, 200 yds. and No. 3, 50 yds. off. Hence $\frac{P'B}{PQ} = \frac{2200}{50} = 44$.

The whole range $AB = 2400$ yds.

$$\frac{AB}{AP'} = \frac{2400}{200} = 12$$

$$\therefore PP' = \frac{44}{12}\,QQ' = 3\,\tfrac{2}{2}\,QQ'.$$

* According to the rigorous "Method of Least Squares," the probable error of the combined observations should be the square root of the sum of the squares of the separate observations.—*Vide* "Merriman's Method of Least Squares."—EDITOR.

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And if No. 3 is two yards out of the line, to the right, No. 1 will have to move 7½ yds. to the left. Only I would not bother a No. 1 with any rule of thumb whereby to calculate this—they have enough to remember as it is.

Of course errors would be made, but with care they could easily be reduced to immaterial dimensions. It is no use straining at a gnat and swallowing a camel. If our picket is laid even ten minutes right or left an equally great error might be caused by a gust of wind; and even at 2400 yds. this would only mean 20 ft. right or left, which would as rule matter very little, even if the range were correct (which it is certain not to be at first). After this round, the line can be corrected by giving deflection in the ordinary way (by the rule—"reduce error (at target) to inches and divide by number of hundreds of yards (to target)." These corrections would be signalled by an observing party to right or left, on the crest of the hill.

I have already written more than I meant to on a subject which will not be new to anyone. The point I specially wish to bring forward, is the importance of having such points embodied in the drill book, and constantly practised at drill. Surely it is of greater importance than even ranking past by sections?

PHOTOGRAPHIC "INSTANTANEOUS SHUTTERS."

BY

LIEUT. E. T. DIXON, R.H.A.

In the October number of "Proceedings" there is a paper of mine on "Instantaneous Shutters" used in photography.

In the paper in question I assumed—somewhat rashly as it turned out, that the value of the exposure during the period that the aperture was being opened and closed was half the value it would have had if it had been open up to the last moment, and then closed instantaneously.

This of course would only be exactly true if the aperture were rectangular. Further investigation by the aid of the integral culculus shows that it is considerably wrong in the case of circular apertures.

I need not give the whole calculation. In the form of slide I was considering, the result is that instead of the formula—

$$W = Tb^2 - \frac{b^3}{v}, \text{ I get}$$

$$W = Tb^2 - \frac{8b^3}{3\pi v},$$

from which I deduce that to get the maximum effect with a slide of a given velocity we should have

$b = 3{\cdot}66a$; instead of $b = 2a$, as I found before.

The principle of the remainder of the paper is of course unaltered, though all formulæ and examples would have to be corrected. It shows even more strongly the error of having wide slits in the shutter which gives the exposure.

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REPLY

TO THE

PRIZE ESSAY OF 1886-87.*

BY

CAPTAIN H. C. C. D. SIMPSON, R.A.

Preliminary observations

In the current June number of the "Proceedings," we were informed that a judging committee, consisting of Major-General Stirling, C.B., Major Powlett, and Major Duthy (President of the late Mountain Battery Committee), had selected the essay written by Captain White as worthy of the gold medal, of the nine Prize Essays submitted. Apparently from nothing further being stated in the notice, not one of the eight remaining essays were considered worthy of honourable mention. We are, however, promised a review of them by a sub-committee, should their (at present) anonymous authors be unanimous in giving their consent. The year chosen for such a subject as "Mountain Artillery," was an unfortunate one for Mountain Battery officers in India; more than half of whom were on active service in Burmah, and therefore either had no leisure to compete at all, or were only able to send in essays insufficiently thought out, and deprived of the advantage of quotations and assistance from books of reference.

Captain White's essay may be described as an intelligent translation of foreign works of reference, with plates, on the Mountain Artilleries of Europe, and with the views of the Mountain Battery Committee, (of which he was a member), from which sources he has drawn some useful deductions of his own. The most novel of these latter, is a list of different establishments providing for so many different conditions of warfare and climate, that it seems a pity that he did not bear in mind the fact, that Mountain Artillery is never likely to be wanted for active service in Europe. His remarks on draught in Mountain Batteries, in his essay and subsequent article, are however, most instructive, and well worthy of consideration and practical trials. Amongst his various suggestions for transport, under certain conditions for Mountain Batteries, I am surprised that he has not mentioned some modification of the principle tried by General Lawson, for carrying his light field guns in Egypt, in 1801. He (Lawson) says, "owing to the acknowledged difficulty of travelling wheeled carriages "in Egypt, we tried a number of contrivances, and amongst others, "horse, or mule barrows, or litters, which we constructed in the

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* Received too late for last month's Number of "Proceedings."—*H.H.C.*

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following manner. We cut pine into long pieces of scantling, 16 feet in length and about four inches square. Something near the shape of a common hand-barrow, preserving the grain as entire as possible. Two moveable cross-bars, which are secured by two small bolts, kept these shafts at a proper interval, to admit a horse between them. The drawings show the figure and manner of travelling the machine by two horses or mules, each having a small cart, saddle with girth, back-band, breastplate, and crupper, and a halter for leading them by. These barrows were particularly useful for narrow paths, for conveying a small piece of ordnance, &c., too heavy for a single horse. (Fig. 1.)

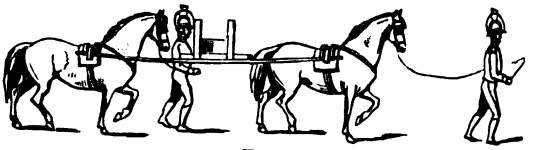

FIG. 1.

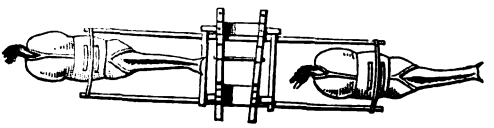

FIG. 1.

Besides these single barrows, a design was formed for double ones, consisting of three shafts, as seen in the drawing (Fig. 2), to be carried

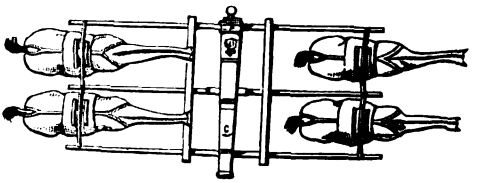

FIG. 2.

by four horses or mules in pairs." By an adoption of the plan in Fig. 1, it would be possible to carry a 4-cwt. gun, and with the arrangement in Fig. 2, an 8-cwt. gun. I merely mention this *en passant*, and have not considered the doubtless many disadvantages such a mode of transport would have for Mountain Batteries, even though only tried in open, and not mountainous countries.

Detailed criticism.

I will now take Captain White's essay in detail, and try and stimulate a useful and friendly argument, by criticising some of his statements and suggestions. He commences his essay by quoting from a book not yet officially published, the "Hand-book of 2·5-in. jointed gun, Imperial Service, 1887." The only official information of which officers can avail themselves, is that given in the following books:—

"Handbook for Field Service, 1884," (recently cancelled), Part 1, Vol. I., Field Artillery. The "Manual of Mountain Artillery, 1882,

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India," corrected to date by various Indian General Orders; "Equipment Tables, Mountain Batteries, India, 1884," and Major Radcliffe's "Hand-book for jointed gun batteries, Colonial Service, 1887."

Captain White's statement as to the lavish scale of Indian requirements, with reference to the number of mules required for a Mountain Battery in India, we traverse entirely, and it is a favourite form of argument against the permanent formation of Mountain Batteries at home for depôt, or active service in Africa or Western Asia. The total number of ordnance mules and riding horses for a screw-gun Mountain Battery on a war establishment in India is only 144, and it would be just as absurd to state that the country could not afford to keep up Horse Artillery on account of its expensive equipment and number of horses (183).

Baggage mules.

The baggage mules should not have been mixed up with the battery mules, as they have been for years separated from them in India, and belong to the Transport Department, which now provides on service whatever transport for baggage is deemed the most appropriate for the country and climate, in which operations are to take place, and as the baggage of Mountain Batteries always travels with that of the other troops of a field force, along the line of communications, which is almost always (even in the hills) more or less a good road, the transport may consist of camels, light carts, or mules, whichever is most suitable.

I shall not, therefore, go into the question of baggage mules, beyond stating that his remarks are useful for the Transport Department, though it is not quite evident why he requires twice as many mules for stores in scale *C* than in scale *B*, or why charcoal is alone wanted in the former scale. More mention might also have been made of tentage, while he was on the subject of baggage mules.

Ammunition columns.

His remarks about mules of batteries of Artillery turned into ammunition columns, I also will not comment upon, as I hope on the re-organization by the Q.-M.-General of the Transport Department, officered by combatant officers, that all reserve ammunition for an army in the field may be carried by this Department, and that batteries of Artillery will be left to perform their legitimate duties.

Establishment of ordnance mules.

The question to be considered, therefore, is the number of ordnance mules which Captain White considers necessary for a battery. The only contested points are the number of relief mules, and spare unsaddled mules, required by a battery for prolonged service in the field. In his *A*, *B*, and *C* scales of establishment, he makes a novel suggestion, by way of compromising the first difficulty, by an ingenious combination of the loads of relief and ammunition mules.

But there are two fatally weak points, in my opinion, in his argument:—

1. He proposes that the men should carry a kit, and their great coats, the latter of which are usually carried on the relief line. Now if it is considered inadvisable that a gunner of Field Artillery (although he is often carried on the carriages, and even when on foot marching over roads or comparatively good ground), should carry any load, is it reasonable to expect a mountain gunner, who is always on foot, moving over

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rough or hilly ground, and lifting heavy weights, however athletic he may be, to carry a greatcoat and a kit, which, as the former alone weighs 8 lbs., would make a total weight of certainly more than the 10 lbs. claimed by Captain White. Even as it is, a No. 1 of a Mountain Battery has often been likened to a Christmas tree, slung as he is, with a revolver and ammunition, sword and telescope, sights and spring spikes, havresack and water bottle, and the difficulty is at present to find room on his person for a mess tin. How then can we expect him to carry a kit? As regards a load checking a man overwalking an animal on a down-hill slope, my experience is that it rather aggravates than checks the fault, and certainly tends to prevent him keeping up when ascending a steep slope.

(2). He wishes four rounds of case shot to be carried on the axle mule, and three rounds of star shell on the relief wheel mule. This also is a puzzle to me; as the only place available for the former is the small store box, which contains at present a large quantity of small-arm ammunition, which replaced, some years ago in the Indian equipment, the case shot suggested by Captain White, but which, to be just, is in about the last place in which the box is wanted. On the top of the cradles of wheel and relief wheel mules, respectively, the implement box and hold-all are carried. Where then is he going to put one of these articles, if he carries the star shell on one of them?

Now as regards any alteration of the present load of the axle mule, it should be towards abolishing the small store box. It contains nothing except tubes, wanted in the first line when the guns are in action, and the tubes could be carried in the implement box, which is almost empty at present, but still not large enough for rounds of ammunition. To balance the axle (weight about 79 lbs.) with the dismounting block (11 lbs.), a gun portion of 68 lbs. weight (of which more anon), to convert the gun into a howitzer should be carried, thus carrying out to some extent Captain White's idea, expressed later on in his essay. The elevating gear should be carried on the top of the cradle with the trunnion block.

Relief. I may state that the weight of the combined relief and ammunition mule load, as suggested by him, is greatly under-estimated at 132 lbs. Putting the weight of the eight fuzes, projectiles, and cartridges, &c., including their bags and paper coverings at 72 lbs., this only leaves 60 lbs. for the weight of the line gear and saddle tarpaulins of two mules, spare sponges and lifters, &c., carried on the relief line. The weight of the relief mules' loads at present is an average of 150 lbs., or about the weight of the load of the wheel mules in a 200-lb. battery. This of course includes 35 lbs. of great coats which Captain White wishes to do away with; but even so, the load would not be an insignificant one at 115 lbs. for "relief."

Draught. His remarks on draught are exceedingly instructive. But, after all, we can only look upon draught as a subsidiary means of transport, to easing the top loads of the mules of the first line, whenever the nature of the roads will permit; and if the country in which operations are taking place permits of the invariable use of shafts, and thus

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the unnecessary employment of relief mules, it becomes a great question whether it would not be better to employ a light Field Battery which could move about at an increased pace. I shall say more of draught later on, but I merely make these remarks here in order to show that in considering the mule establishments of a Mountain Battery for universal service you must provide for a relief line, which when marching in relief carries a reasonably light load. To quote Foreign nations in this respect is hardly fair, as their mules are overloaded. The weight of the carriage in Austria, for instance, is 240 lbs., and this is transported on one mule, far in excess of what experience has taught us to be a fair "top" load.

Bare-backed mules.

He has reduced the number of bare-backed mules by six below the Service allowance, which I consider can be done, provided these bare-backed mules are *kept* bare-backed, and not loaded with heavy bags of spare line gear and material, as they are in India at present. I therefore would adopt for all conditions of country and warfare, his establishment of ordnance mules suggested in his scale *D* for a battery on war establishment, at which strength all batteries abroad should be maintained. But for the peace establishment of a battery on home service, combining the duties of a Depôt and Service Battery, the number of ordnance mules might be reduced to 73 by the non-maintenance, in time of peace, of the relief, spare carriage, and bare-backed mules (*see* my suggested establishment later on), and even lower with 4 guns.

Riding horses.

In his list of riding horses, or as I should prefer to see them styled (as in India officially) "small horses," under which heading is included handy little animals such as galloways and cobs not under 13·3 or over 14·3 hands, up to weight and sure-footed, I should like to see the shoeing-smith and not the collar-maker mounted, both in peace and war; the collar-maker's work on arrival in camp being of a sedentary nature, and that of the shoeing-smith a very active physical one. He has only recently been mounted in India, under the supposed idea that he had more work to perform on the march than his dismounted brother in a Field Battery. But now, if the pads are well fitted, and the drivers know as they should, and do, in most batteries, how to settle the wool in their pads, his work is not so abnormally great. The shoeing-smith on the contrary has a great deal to do in attending to feet and watching for any symptoms of girth or shoulder swellings, to say nothing of the usual accidents and ailments on a march, both to animals and material. This would make the number of riding horses for peace 11, and war 12.

Personnel.

In considering the *personnel* of a battery, all officers will agree with the writer of the essay in his desire to reduce to a minimum the number of men compatible with the efficient working of the battery. This has been very carefully considered in India, and their establishment agrees with his own until we arrive at the number of his gunners and drivers. Eighty-two gunners are quite sufficient for the service of the battery; and as regards drivers, whom I should like to term, although enlisted men, muleteers, (the proper cognomen of a man,

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whether a soldier or civilian, who leads and takes care of a mule), you must have one man per ordnance mule, and for war service a few spare. Even this arrangement of only 5 p.c. spare, leaves the riding horses to be looked after by the gunners, and a number of mules with unimportant loads, owing to absence or casualties of the drivers or muleteers.

Of course in India, and indeed wherever batteries are kept up permanently abroad, the drivers or muleteers should be native subjects of the country in which the battery is serving, and enlisted men, with a small staff of their own N.-C.-O.'s, as in India. For a home service battery you must have of course Europeans and interchangeable gunners and drivers or muleteers to permit of every man serving with a battery abroad as a gunner as suggested by Captain White. We thus arrive at an establishment of 76 drivers or muleteers for a battery on a home peace establishment, and 140 (including 5 p.c. spare), for a war establishment at home or abroad.

It is not quite apparent why Captain White requires three wheelers for a Mountain Battery where there are no travelling carriages, when only two are deemed necessary for a Field Battery on a war establishment, and I think it would have been better if he had made his establishments of shoeing-smiths 3 (as even when not shod, mules feet require careful attendance) and his wheelers 2.

ganiza- n by igades.

The organization of Mountain Batteries by brigades, and the number of batteries which should be kept up permanently in a brigade, is very lightly considered in the Essay, owing perhaps to the fear of tenderly treading on the toes of a wider organization which is now being treated of in committee. A delicate allusion is made to the Mountain Batteries of Spain, in the West Indies, and we are left to draw our own inference. This is, that there is very little doubt that the present eight years' service system of Garrison Batteries with mountain equipment is eminently unsatisfactory for all concerned, and that the eight screw gun batteries in India and the two in the Colonies (one Natal, H/4, and one—formerly Mountain and now Garrison—in Egypt), should be formed into one brigade with the battery at home on the peace establishment to act as a Depôt, for supplying the gunner establishments of the batteries abroad, and as a service battery capable of expansion for active service on an emergency. The batteries abroad would be relieved amongst themselves, and as their gunner establishments would serve a certain time at the Depôt, before going abroad, the Europeans would all have a proportion of home service in their eight years Army Service. On the evacuation of Egypt, 3/1 Northern battery at present at Cairo and Alexandria, might be transferred to Cyprus as a Mountain battery, handy for any little expedition in Western Asia, or Northern Africa, and commanding the mule supply of South-Eastern Europe and Asia Minor. The combined Service and Depôt battery, 2/1 South Irish (*M*), now at Aldershot, is necessary to supply the recruits of the gunner establishment of the batteries abroad, more satisfactorily than they are at present, to test all new mountain equipment sent to the batteries abroad, and is ready to be

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despatched with the numerous little expeditions that are always taking place in unforeseen localities. In the event of this battery being sent abroad, under the circumstances here stated, the Lieut.-Col. and Adjutant at the head-quarters of the brigade (Aldershot) with a small training staff, should take charge of the instruction and supply of recruits. This arrangement would form a mountain Brigade of 10 Service and 1 Depôt Service Batteries. The Mountain Brigade should remain as at present, in the Garrison Artillery branch of the Regiment, it being a special service, the most requisite qualifications for which, pertain more to the foot than the mounted soldier.

Captain White recommends that "the dress should be similar to that worn by Mountain Batteries in India." But he should have added "a suitable church-parade and walking-out dress should be provided for them." Although the most serviceable dress in the British Army, there is no dress more unpopular among the rank and file of Mountain Batteries than their present one, for these reasons :— Dress.

1st. There is no full dress, the only difference being that the dress worn on full dress occasions, though exactly similar in cut to the drill order, is made of cloth instead of serge, but is without any trimmings, or additional buttons, &c.

2nd. The serge suit should be issued annually instead of biennially, as one suit will not last two years.

3rd. The men do not fancy walking out and going to church in knickerbockers and gaiters, which they look upon as as great an anomaly of dress for these occasions as a cavalry soldier would his pantaloons and jack-boots.

For full dress and walking out, they might have a pair of trousers and Wellington boots; and their present full dress Norfolk jacket, (which might be issued triennially) should be trimmed similar to the Garrison Artillery tunic. This would enable the men, like the officers, (who only wear their Mountain Battery dress on drill parades, and the dress of the mounted Garrison Artillery officer on all other duties), to wear their knickerbockers and gaiters only on drill parades. The full dress knickerbocker might be abolished.

The mounted men should have breeches cut like the officers, instead of knickerbockers, and a pair of box-spurs issued to them to be worn with the overalls alluded to above. In temperate climates the field boots of the officers, and the gaiters and boots of the men might be of black instead of brown leather.

We do not agree as to the arming of gunners with pistols. They are only an encumbrance on the march to the men, and are open to the numerous objections which have been urged from time to time by officers in these "Proceedings." The present curved Mountain Battery sword which Major Sorrell recommended recently for all gunners, is a sufficient defence for men attacked at close quarters, and are useful in cutting down obstacles. A double-barrelled Lancaster oval-bore pistol might be given to the mounted men. Three carbines per sub-division are necessary for baggage guard, foraging escort duty, and "sentry-go" at night. Arms.

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nament. It must be remembered that except perhaps in the far East we should never want to employ Mountain Artillery against a European foe. Our usual opponents have a very indifferent Artillery, and perhaps none at all. The present screw-gun is the most powerful mountain gun in the world; its only defect being that we cannot employ high-angle fire, as with its little brother the 200-lb. gun. Let us therefore, as Captain White suggests, retain the latter for the Native Batteries in India, and retain the screw-gun for our Mountain Brigade, endeavouring to convert the latter on occasion into a howitzer by the substitution of another piece for either the breech or chase portions. The double shell of the 200-lb. gun is effective at short but not so at long ranges. If the gun were increased by one third its present weight, this might be probably effected. The problem that Artillerists have to solve is this. How to convert a jointed gun of two pieces, each weighing 204 lbs.—when required as a temporary measure—into a jointed howitzer of 272 lbs. total weight, by substituting for one of the original pieces, another of one-third its weight, and by any alteration or addition to the remaining gun portion or carriage not affecting the serviceability of the two original pieces when forming a gun.

I have shown how this extra howitzer portion of 68 lbs. could be carried on the axle mule, and I entirely endorse all Captain White's remarks on the evils attending the increase of the number of pieces forming a gun. A mixed equipment as has been now introduced into the Punjaub Mountain Batteries, I consider open to more objections with Mountain Artillery working on a hill-side, than in the old days it was for Field Artillery, and with a detached Division you are liable to have just the gun you don't want, under the circumstances, with it.

From experience in Burmah, I consider a more sensitive percussion fuze for use with the common shell, when attacking stockades, or lightly constructed obstacles, is necessary for the screw-gun.

munition Assuming that the screw-gun, which I feel certain is possible, can be converted into a howitzer, I would suggest the following arrangement for carrying the ammunition, which would be a compromise of the two present systems of packing the screw and 200-lb. guns:—

On the first five ammunition mules of a sub-division, I would carry 50 rounds of shrapnel, 20 rounds of common shell, and 10 rounds of case shot, *i.e.*, five rounds shrapnel, two rounds common shell, and one case shot in each box; on the 6th ammunition mule, should be carried 10 rounds double shell.

A small box to contain four rounds of star shell should be carried on the top of the cradle of the relief axle mule of each sub-division. Total, 94 rounds per gun, or 564 per battery.

By the doing away of the small store box, the tubes should be carried in the implement box, a certain number for immediate use being carried in the lanyard pouch of No. 5.

The small-arm ammunition, with the exception of 10 rounds in the pouches of the men carrying carbines or revolvers, should be carried in the store boxes with the baggage.

riage. I consider that any form of carriage that will bring the weight

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lower on the animal's back, and if possible, to some extent on his sides, will be a great advantage, as the present carriage load is the most awkward in the battery and very trying for the mule.

Besides Major Clavarino, Captain Birch has also a suggestion, which was tried I believe in India, for doing away with wheels, and substituting trucks on the carriage—but I do not know that it has proved a success. I have never seen any difficulty in keeping the screw-gun under control with check ropes and drag ropes, when fired on any ground, however difficult.

In continuation of my remarks on draught, Captain White in his essay, and later article, although strongly advocating the use of draught, only gives us one suggestion of his own, how to apply it. Without experiment, it is impossible to criticise it fairly; but it would seem that these must be great strain on the pin fastening the pole in the handspike socket, when going over anything but very level ground; and that in going up ascents the muzzle of the long screw-gun would be liable to scrape on the ground from the small diameter of the wheels of the carriage. On paper, I fancy most the plan improvised by H/4.

We must remember that although Russia employs draught to a great extent in her Mountain Batteries that she requires three mules for the transport of the carriage and wheels, which in her system only weighs 420 lbs., which would seem to prove that her arrangement for shaft transport weighs very nearly a mule load. To employ draught, therefore, with Mountain Batteries, you must have a simple arrangement, which will fulfil the following conditions :—

A. To enable the change from pack and draught transport to be made with ease and rapidity.

B. The weight of the system to be such as not to interfere materially with the mode of carrying, or increase the weight to any extent of the present mule loads.

C. Not increase the number of the mules.

Perhaps the Carriage Department can suggest something of this sort which would assist in the relief of the top-loaded mules.

Small store and side arms.

The remarks in the essay on the small stores and side-arms are very short. As we have already stated, the small store box with its contents can be disposed of as we have hinted, and the present half empty implement box can carry the tubes.

Some arrangement should be made for carrying small articles of spare harness for use on emergency with the first line. A better arrangement is also wanted for carrying the trunnion block, and perhaps I may be permitted to commend my own plan as adopted in 7/1 N.D., R.A.

The leather pattern boxes for ammunition, stores, &c., are much superior to those of wood covered with painted canvas of Clarkson's. They weigh considerably less, and are much less liable to injury from the fall of a mule, &c. The muzzle bearer of the Indian pattern is preferable to the tampeon of the English pattern, as a man has not to lean over the mule, and has a greater leverage for lifting the

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weight. The leather apron (new pattern) is preferable to the top heavy frame for pioneer tools.

Harness. Captain White suggests the re-introduction of the Newmarket bit. The opinion of the majority of Mountain Battery officers was that it was a failure; so it was withdrawn from the Indian equipment, and Colonel Frees' convertible snaffle bridle and sliding leather rein introduced. It can be used either as a leading rein or as a watering bridle, when the mules are ridden out to exercise or to water. Why the Newmarket bit, which is only used for breaking in colts with light mouths, was ever introduced for controlling an animal with the hardest mouth in the world—the mule—has never been quite clear. The old pattern leading rope was always tearing out from its leather piping and difficult to keep clean and smart-looking on the march.

The Austrian arrangement of combined crupper and breech piece is, I should think, well worth a trial, and an improvement might be introduced into the present breast-piece, which is at present absolutely useless. Leather striped girths only should be issued, and the web girths which grow hard with sweat and cut like a knife should be abolished.

The best form of quilting for the pads I have seen is the one used in 7/1 N.D., R.A. It is quilted to the breadth of a few inches all round the sides and ends, and the stuffing is altogether taken away for a few inches breadth at the top. This enables the pads to be girthed tight to the figure of the mule, and allows a large air-space along the back. Greater care should be taken in carding the wool before stuffing the pads.

Cradles. I do not agree with Captain White as regards the English cradles. They were sent out to India in 1885, and under the direction of the D.-A.-G., R.A., in India, I carried out experiments with them in the battery I was temporarily commanding at Jutogh, and they were certainly considered superior to the Indian pattern. They weighed cradle for cradle, without their mechanical attachments, about the same as those of Indian manufacture, but were more business-like and smarter-looking in appearance, and brought the top loads lower on the animals backs. The mechanical attachments are a mistake, as they increase the weight of the cradle unnecessarily, and straps and leather loops are infinitely preferable as they practically never break, and even if they did, can be easily and quickly repaired.

On the mule falling, the mechanical attachments either bend or break, and require elaborate repair in the artificer's shops, and certainly could not be replaced in "action" like the others.

I don't fancy metal cradles, for as it is, whatever metal is used in the present cradles, is always bending or breaking, especially in the ammunition cradles.

The staff pattern saddle with brass cantle is preferable to the large universal heavy cavalry saddle, and the greatcoat is conveniently carried on the fans in rear, with glasses, over the off-shoe pocket. The breast plates should be of hunting pattern, the ordinary breast-plates being useless for steep ascents.

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The best pattern range-finder for Mountain Batteries is the "Weldon," lighter and more portable than the "Watkin." A simple pattern pocket aneroid, reading up to 7000 feet, should replace the complicated unwieldy instrument, which few understand, now in use. Range finder

I have nothing to say except in praise of Captain White's remarks on the "Tactics of Mountain Artillery," which are somewhat similar to those contained in that excellent work in the R.A. Institution on "Mountain Warfare in Switzerland." For a practical illustration of the tactics that should be adopted by a battery in action on the mountains, I recommend to all interested the account of the action of Zara, in the Zaimukht expedition; the first instance in which the screw-gun was used in action. Tactics.

In Burmah the screw-guns have, in my opinion, had no chance, having been as a rule brought into action at too short ranges, thereby nullifying the advantage of their great range, for preparing the attack for the Infantry.

Of parade movements, no mention is made. In my opinion the 2nd ammunition mule should form part of the 1st line, for this reason:— The guns are in action, and one mule load of ammunition (14 rounds of shell) is exhausted. The 2nd line is necessarily some distance in rear. If there is a second ammunition mule with the sub-division the gun can continue in action firing, whilst the first mule goes to the rear, and is replaced by the 3rd ammunition mule, and so on. Otherwise whoever is in charge of the "ammunition line" some distance in rear, is uncertain when to replenish the "1st line," not wishing to expose more mules than is necessary, and yet afraid to delay the supply of ammunition, lest the 1st mule boxes be emptied.

When working with Field Artillery with a force in the field, any Mountain Battery there may be, should be attached to the Infantry Brigade with the most important objective, accompanying it, and ready to come into action at any important moment, and not be brigaded with the F.A.

Three cardinal points should be observed with Mountain more than any other Artillery:—

1st. When once in action the battery should rarely change its position.

2nd. As its pace is a walk, great care must be observed that skirmishers are not allowed to creep up anywhere near the flanks or rear of 1st or other lines.

3rd. That it can support the Infantry at close ranges.

In conclusion, I trust Captain White will not think any of these numerous remarks unfriendly, as all M.B. officers must agree with me that his essay is instructive and most interesting.

[War Establishment, &c.

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Peace and War Establishment of a 6 2·5-in. M.L.R. Gun (convertible into Howitzer) Battery,—an amendment on Captain White's.

Distribution.	Peace. Home.	War. Abroad.
Officers.		
Major	1	1
Captain	1	1
Lieutenants	3	3
Total	5	5
N.-C.O.'s, Men, and Artificers.		
Sergt.-Major	1	1
Q.-M.-Sergt.	1	1
Sergeants	6	6
Corporals	6	6
Bombardiers	6	6
Trumpeters	2	2
Gunners	82*	82
Muleteers (enlisted)	73†	140†
Farrier Sergeant	1	1
‡Collar-Makers	2	3
‡Wheelers	2	2
‡Shoeing-Smiths	2	3
Total	184	253
Small Horses (Riding).		
Officers	5	5
Staff Sergeants	2	2
Farrier	1	1
Shoeing-Smith	1	1
Trumpeters	2	2
Spare	0	1
Total	11	12
§ Ammunition.		
Rounds per gun. shell — Common	20	20
Rounds per gun. shell — Shrapnel	50	50
Rounds per gun. shell — Double	10	10
Shot, case	10	10
Star shell	4	4
Total per gun	94	94

Distribution.	Peace. Home.	War. Abroad.
Ordnance Mules. ‖		
Gun, 1st line	12	12
" relief	0	13
Carriages, 1st line	6	6
" relief	0	6
Axle, 1st line	6	6
" relief	0	6
Wheel, 1st line	6	6
" relief	0	6
Ammunition	36	36
" relief	0	6
Pioneers	3	3
Artificers	3	3
Spare carriage	0	6
Forge	1	1
Spare (bare-backed)	0	18
Total ¶	73	133
Saddlery and Packs.		
Staff pattern saddles. Officers	5	5
Staff pattern saddles. Mounted men	6	6
Total	11	11
Ordnance saddles of sorts	73	115
Carriages.		
Gun (including 1 spare for war)	6	7
Boxes.		
Artificers	6	6
Ammunition	72	73
Implements	6	7
Star shell box	6	6
Small and Side-Arms.		
Swords, M.B. pattern (at 1 per man)	184	253
Revolvers or pistols, P.B., (1 per mounted man)	6	6
Carbines, Martini-Henry, (3 per sub.)	18	18
Cartridges (S.A. Ball, B.L.)	360	360
Cartridges (D.B. pistol)	360	360

* To this number must be added the number of gunners extra required for the batteries abroad every year.

† On the English establishment, these muleteers would be interchangeable with the gunners, and available for service abroad. Abroad, the muleteers would be natives of the countries in which the batteries were serving.

‡ Abroad, all the artificers excepting Farrier and head Collar-maker, would be natives.

§ 50 per cent. extra on service carried by Transport Department.

‖ If only 4 guns were kept up by the battery at home, and 8 ammunition mules, &c., 35 mules and 37 drivers would suffice.

¶ On the expansion of the battery at home to war strength, the Transport Department should supply the necessary number of broken-in mules.

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